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STATE-OF-THE-ART: MILITARY EXPLOSIVES AND PROPELLANTS PRODUCTION INDUSTRY

VOLUME II
Wastewater Characterization

by
James Patterson
Norman I. Shapira
John Brown
William Duckert
Jack Polson

Project No. 802872

Project Officer

Richard Tabakin
Industrial Environmental Research Laboratory - Cincinnati
Edison, New Jersey 08817

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
CINCINNATI, OHIO 45268

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16. ABSTRACT

This study has surveyed the military explosives and propellant manufacturing industry, covering both "GOGO" and "GOCO" facilities. Sources of wastewater, volumes, and pollutant constituents have been reported where such data existed.

Treatment technology currently in use at the various installations has been described, including effectiveness of pollutant removal and secondary (air and solid) waste generation. Systems under development at these military installations have also been examined and evaluated in light of available information.

The report consists of three volumes. Volume I presents general conclusions and recommendations and describes the industry's manufacturing operations. Volume II presents the bulk of the data concerning the wastewaters and the treatment systems now in place. Volume III reviews and summarizes data from the first two volumes and describes and evaluates the new treatment processes under development at this time.

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This project, "State-of-the-Art: Military Explosives and Propellants Production Industry", was undertaken as part of Environmental Protection Agency's Miscellaneous Chemical Industries program to establish a baseline of information concerning the military explosives industry, the magnitude of its waste problems, and the adequacy of the industry's treatment technology. The results of the study have indicated that many of the wastes do present significant problems of toxicity and/or resistance to treatment, in addition to problems unique to explosives. Although some treatment systems in use do protect the nation's waterways from contamination, others are inadequate, generate secondary air or solid waste problems, or are not widely used due to budgetary limitations. Further research effort is needed by EPA and/or Department of Defense to control pollutants generated by certain sectors of the industry. The data and results of the investigation have been used extensively by EPA's Office of Water Programs in developing standards for the explosives industry. It will also allow engineering staffs at several commercial military manufacturing facilities to examine their wastes and compare control technology with that being used or developed at other installations. Finally, it will enable EPA to determine our own research efforts in this industry and how they would relate to other programs. Questions or requests for additional information should be directed to the Industrial Environmental Research Laboratory - Cincinnati, Field Station - Edison, New Jersey.

David G. Stephan
Director
Industrial Environmental Research Laboratory

ABSTRACT

This study, contained in three volumes, addresses the wastewater effluents of the military explosives and propellants production industry. Both manufacturing and LAP (Load, Assemble, and Pack) activities are covered. Volume I describes the industry, as well as the production processes and technology. Volume II details the wastewater effluents of manufacture and LAP operations by product, process, and military installation, to the extent that data are available. Volume III describes and evaluates the effectiveness of various treatment technologies for water pollution abatement now in use or under investigation by product, process, and military installation.

A comprehensive long-term effort has been underway by the Department of Defense for a number of years for the purpose of modernizing munitions production plants. Pollution abatement is an integral part of the modernization program. Although extensive study, research and development investigations have been undertaken, and although significant water pollution abatement and water management plans have been developed, implementation is generally in only the initial stages at selected military facilities. Major Government emphasis and very substantial funding are essential to: the continuation of necessary pollution abatement research and development; the demonstration of promising new treatment technologies; and the implementation of effective and economical treatment system construction programs. Recommendations are set forth in detail in Volume I.

The reader of this report is advised that it consists of six chapters, contained in three volumes, each addressing separate aspects of the explosives and propellants wastewater effluents and treatment situation, and that duplication and repetition among these chapters has been kept to a minimum. Thus, the reader is cautioned that the use or interpretation of statements or evaluations taken out of context from the study in its entirety could lead to serious misunderstandings and incorrect assessments.

VOLUME II

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SECTION I - INTRODUCTION

1. Chapter V contains detailed characterizations of the liquid effluents generated in the manufacture of explosives and propellants and load, assemble, and pack (LAP) operations at various ammunition plants.

a. Section II of Chapter V contains summary characterizations of the waste water effluents by product or process. Detailed characterizations of products and intermediates are grouped by category in Sections III-VI as follows:

Section III	Acids
IV	Explosives
V	Propellants
VI	Load and Pack

b. The effluents are described on a product basis for each of the following materials: acetic anhydride; ammonium nitrate; blends including RDX and HMX, and explosive formulations derived from them; concentrated acetic acid; concentrated nitric acid; concentrated sulfuric acid; dinitrotoluene (DNT); nitrocellulose (NC); nitroglycerin (NG); nitroguanidine (NGu); oleum; primers, including trinitroresorcinol (TNR), lead styphnate, tetracene, and pentaerythritol tetranitrate (PETN); single base propellants; multi-base propellants; solventless propellants; tetryl; TNT; and weak nitric acid. In addition, effluents from LAP operations are described on a plant-by-plant basis. Detailed data tables are included in Appendix I.

2. Table 1 lists the various plants, their locations, and their principal activities. Complete coverage of plants listed in Table 1 has not been possible because of lack of data from several of the plants. Where a discussion of the wastes generated in the manufacture of a specific material at a specific site has not been possible, an asterisk appears instead of the X in the box (see Table 1).

3. A large volume of data characterizing liquid effluents primarily from the Army explosives production industry have been generated. However, because of mixing of effluent streams it was not always possible to associate these data with the production of specific materials. The information presented in this chapter was derived largely from AEHA reports of various vintages. Where production figures were available, they were incorporated into the data base. It may be anticipated, however, that production (generally reported as percent of full mobilization capacity) today is substantially less than the data reported in this chapter, since the data presented herein are based on AEHA studies undertaken primarily during the conflict in Southeast Asia. Furthermore, the data presented in this chapter do not reflect large fluctuations in effluent composition with time. These fluctuations may result from variations in production rate, periodic shutdowns, or periodic washouts. Flow rates may vary for these same reasons.

This chapter contains the most complete and thorough product-based wastewater characterization that can be presented without further detailed monitoring and analytical work. There are many data gaps in the following text, and they are noted and can constitute specific subject areas for future investigations.

4. Much of the information presented in Chapter V is in tabular form. These tables generally present a chemical characterization of the liquid effluents from a specific step in the manufacture of one of the above-mentioned materials prior to treatment. This characterization may include: constituents; maximum, minimum, and mean concentrations; mean concentration corrected for the mean raw water concentration; discharge in lbs/day; lbs of discharge per ton of final product; flow; and production. Results from these tables may then be summed to yield the overall discharges (in lbs/day

and lbs/ton of product) resulting from the production of each material. These overall discharges may then be cross-correlated among the various plants. In only a few instances, however, were enough data available to complete all of these tables. In many cases, wastewater characterizations for the manufacture of a specific item were available for only one plant -- the data from the remaining plants manufacturing this item were incomplete or non-existent.

5. Table 2 summarizes the major constituents in the untreated effluents from each AAP. This is only a qualitative evaluation and is based on the results presented in this chapter.

a. Data from Navy munitions facilities are not available in sufficient detail to be meaningful, since the Navy monitoring program is in an initial implementation stage in most cases. However, four of the six Navy facilities are LAP only, and the effluents of these plants can be assumed with validity to be comparable to the effluents of Army LAP plants loading the same ingredients. Indianhead is primarily a propellant facility; however, data are not available.

Table 3 lists the Army Ammunition Plants and their abbreviations.

TABLE 1

AMMUNITION PLANTS AND THEIR ACTIVITIES

Ammunition Plants	Activity					Product Capability																			Ingredients Used in Formulations																
	Manu.			LAP		Acids						Explosives							Propellants																						
	Acid	Explosive	Propellant	Explosive	Propellant	Acetic anhydride	Conc. Acetic Acid	Conc. Nitric Acid	Weak Nitric Acid	Conc. Sulfuric Acid	Oleum	DNT	TNT	NG	Tetryl	RDX	HMX	NGu	Primers	NC	Single Base	Multibase	Solventless	Composite	Aluminum	Ammonium perchlorate	$CaCl_2$	DNT	HMX	NC	NG	NGu	NH_4NO_3	Ammonium picrate	Polybutadiene	Polyurethane	RDX	Solvents	TNT	Wax	Sodium Nitrate
Badger	X	X	X					*	*	*	*			X						X	X	X	X					*													
Holston	X	X				X	X	X	X							X	X												X				*				X		X	*	
Iowa				X															*						*				*								X		X	*	
Indiana	X		*					*	*	*										*	*																				
Joliet	X	X		X				*	*	*	X	*	X		X				*						*												X		X		
Kansas				X																					*												X		X		
Louisiana				X																																	X		X	*	
Lake City		X		X															X																						
Longhorn					X																				*	*									*						*
Lone Star				X																					*												X		X		
Milan				X																					*												X		X		
Newport	*	X						*	*	*			*																												
Radford	*	X	X					*	*	*	*		X	X						X	X	X	X	X							*										
Redstone					*																			*	*	*									*			*			
Volunteer	*	*						*	*	*	*		*																												
NAD Crane				X																					*				*				*	*			X		X	*	X
NAD Hawthorne				X																					*												X		X	*	
NOS Indianhead		*	*		*									*								*	*	*	*	*			*	*	*	*			*	*	*	*			
NAD McAlester				X																					*								*				X		X	*	
Magna				*	*									*										*	*	*			*	*	*						*	*			
NWS Yorktown				X																					*		*									*	X		X	*	
AF Plant 78					*																			*																	*

TABLE 2
MAJOR POLLUTANTS IN UNTREATED EFFLUENTS AS DISCUSSED IN CHAPTER V

Constituent	AAP														
	Badger	Holston	Iowa	Indiana	Joliet	Kansas	Louisiana	Lake City	Longhorn	Lone Star	Milan	Newport	Radford	Redstone	Volunteer
Total Kjeldahl Nitrogen		X			X								X		
Ammonia	X												X		
Nitrite/Nitrate	X	X			X				X	X			X		
Phosphate		X							X						
Sulfate	X				X								X		
Turbidity															
Color	X									X			X		
Surfactants															
Total Organic Carbon	X	X			X					X			X		
Total Solids	X	X			X								X		
Total Dissolved Solids	X	X			X								X		
Total Suspended Solids	X	X			X								X		
Total Volatile Solids													X		
pH	X	X		X	X					X		X	X		X
Trinitrotoluene		X	X		X	X	X			X	X				
Dinitrotoluene													X		
HMX		X													
RDX		X	X		X	X	X				X				
Acetic Acid		X													
Acetic Anhydride		X													
Acidity		X			X								X		
Alkalinity		X			X								X		
Chemical Oxygen Demand	X	X							X				X		
Biological Oxygen Demand		X							X				X		
Phenols															
Acetaldehyde		X													
Acetonitrile		X													
Methylacetate		X													
Propanol		X													
Propylacetate		X													
Cyclohexanone		X													
Butanol		X													
Toluene		X													
Hexamine		X													
Acetone		X											X		
Nitromethane		X													
Methyl nitrate		X													
Nitric acid		X													
Tetryl			X												
Lead Azide						X				X					
Lead Styphnate						X		X							
Octyl										X					
Potassium Nitrate										X					
Charcoal										X					
Sulfur										X					
Ammonium Perchlorate									X						
Cyanide									X						
Iron									X						
Cadmium									X						
Manganese									X						
Nitroglycerin	X												X		
Lead	X														
Trinitroresorcinol								X							
Tetracene								X							
Ethyl Alcohol													X		
Ethyl Ether													X		
Diethyl Ether													X		
Sodium sulfite													X		
Sodium nitrite													X		
Sodium bisulfite													X		
Sodium trinitromethane sulfonate													X		

TABLE 3

ARMY AMMUNITION PLANT (AAP)

AAAP	Alabama
BAAP	Badger
BuAAP	Burlington
CAAP	Cornhusker
GAAP	Gateway
HAAP	Holston
HaAAP	Hays
IAAP	Iowa
InAAP	Indiana
JAAP	Joliet
KAAP	Kansas
LAAP	Louisiana
LCAAP	Lake City
LHAAP	Long Horn
LSAAP	Lone Star
MAAP	Milan
NAAP	Newport
RAAP	Radford
RaAAP	Ravenna
RiAAP	Riverbank
SAAP	Sunflower
ScAAP	Scranton
TCAAP	Twin Cities
VAAP	Volunteer

SECTION II - WASTEWATER CHARACTERIZATION SUMMARY

6. This Section presents a qualitative summary of the waste water effluents from explosives production, by major product or intermediate. The summaries are complied from the data contained in the various tables in Chapter V, as well as from data on commercial explosives production derived from the EPA Report by J. W. Patterson et al., "Pollution Control in the Commercial Explosive Industry." (4d)

Since they are based on the most complete and comprehensive waste water data available on the military and commercial explosives production industries, the results presented in this Section can be considered as representative. Although data on commercial explosives production plants are included, these are not highly significant in comparison with the large volume of detailed data available on military plants.

7. Data from some plants are not fully useful, since they represent combined flows from several products or processes, rather than individual products or processes. The available specific product or process data were arithmetically averaged (on a flow-proportioned basis) to determine mean values. Maximum and minimum (range) values were taken directly from the raw data sources. Based upon the industry-wide average discharge volume (MGD) and production (TPD), the average effluent concentration was used to calculate effluent discharge in lb/day and in lb/ton of product. The last column in Tables 5-15 represents the number of plants for which each set of data was averaged, and from which ranges were determined. For example, in Table 5 data from four plants were used to determine the mean flow; however, data from only two plants were available on total organic nitrogen. For some products, such as HMX or RDX, there is only one plant for which data are available.

8. The wastewaters are characterized on a basis of products and intermediates. In some cases, a breakdown into individual process wastewater is also included. There is a great deal of variability from plant to plant.

9. The "average" plant is defined on the basis of most common and/or most abundant intermediate and final explosive products, as found in both commercial and military explosive production industries. Although this is only a hypothetical "average" plant, it can be considered as typical of the wastewater of the last decade. It is not, however, representative of a plant after "modernization." "Average" plants producing the following intermediate and final product are characterized in Tables 5-15.

Nitrogen based compounds (ammonia, nitric acid, ammonium nitrate)
Concentrated Sulfuric Acid
Oleum
Acetic Acid
Acetic Anhydride
Nitrocellulose
Nitroglycerin
TNT
RDX + HMX + Composition B (RDX + TNT)

10. Nitrogen Plant

a. Combined wastewater is from the production of ammonia, weak and strong nitric acids, ammonium nitrate. The waste sources include cooling waters and spent acid streams from nitration processes.

b. The waste is acidic with moderate to high nitrate levels as the result of nitration. Sulfate is also present in appreciable amounts. Total solids content of the waste is rather high, compared to the suspended solid concentration, indicating that most of the solids are in dissolved form.

c. Table 5 summarizes available data from all nitrogen plants.

d. The following are characteristics of wastewaters from one weak and one strong nitric acid plant.

TABLE 4 - NITRIC ACID WASTEWATER

Parameter	Weak 61% HNO_3(2)	Strong 99% HNO_3(4)
pH	3.1	3.5
BOD mg/l	less than 4.08	na
COD mg/l	0.1	1.0
Kjel-N mg/l	0.048	0.48
NH_3-N mg/l	0.035	0.34
NO_3 & NO_2 mg/l	5.01	17.7 (15.0 as NO)
TS mg/l	88.95	247
SS mg/l	2.18	1.0
sulfate mg/l	na	33.0
waste flow	9.22 MGD 46100 gal/ton	0.12 MGD 4800 gal/ton

mg/l = ppm and are used interchangeably throughout this chapter

TABLE 5 - NITROGEN PLANTS WASTEWATER DISCHARGE (AMMONIA + NITRIC ACID + AMMONIUM NITRATE)

	Concentration*		Discharge		
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	0.489				4
PROD-TONS/DAY	200				4
GAL/TON	2445				4
pH	2.5	2.3-3.1			
TOT. ORG-N	482	364-600	859	2.9	2
NO2 + NO3-N	206	74-570	210	0.88	4
KJEL-N	27.6	17.9-37.2	147	0.66	2
NH3-N	191	16-532	431	1.58	4
SO4	312	11-850	1758	0.54	4
TOT. SOLIDS	1554	354-2753	4112	286	4
SUSP. SOLIDS	156	4-543	181	0.96	4
BOD	13.5	9.0-18.0	81.5	0.07	2
COD	208	16-556	416	0.92	4
OIL & GREASE	19.1	0.01-42.9	46.4	0.06	3

*All parameters mg/l unless otherwise indicated.

11. Concentrated Sulfuric Acid Production

Although six AAP's conduct sulfuric acid concentration, little data exist to accurately characterize the liquid wastes. One AAP reports no pollutants from the process and has no current or future pollution abatement planned for this production process. Table 6 summarizes available data. The main source of waste is in the purification-concentration area, where excess water from the process is condensed and purged as weak sulfuric acid solution. Three AAP's find the major pollutants to be primarily acid waste.

12. Oleum Production

Raw water is used for cooling in the catalytic oxidation of elemental sulfur to SO_3 gas. Treated water is used for absorption of SO_3 gas. Waste water is generated only by one-pass, non-contact cooling water. Table 7 summarizes available data.

13. Acetic Acid Concentration

a. Wastewater streams include non-contact cooling water, spent process water and sludges. These wastes contain nitromethane, methyl nitrate, acetic acid, n-propylacetate, nitric acid, and trace amounts of RDX and HMX. However, the concentration of these organics is low since they are not detected in the main outfall from the process area.

b. The sludge is generated in the azeotropic distillation process. The sludge contains acetic acid, and heavy metals from corrosion of the distillation column including chromium and copper at sub-ppm levels. Table 8 summarizes available data.

14. Acetic Anhydride Production and Refining

a. Wastewater contains acetic anhydride, acetic acid, acetaldehyde, acetonitrile, methylacetate, methyl nitrate, ethanol, methanol, ethyl acetate, propanol, and propyl acetate.

b. Wastewater sources include cooling and condenser water as well as process water and some sludges. Table 9 summarizes available data.

TABLE 6 - CONCENTRATED SULFURIC ACID PRODUCTION WASTEWATER DISCHARGE

PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	0.258				1
PROD-TONS/DAY	350				1
GAL/TON	737				1
pH	2.9	2.6-9.7			1
SO4, mg/l	25		54	0.153	1

TABLE 7 - OLEUM PRODUCTION WASTEWATER DISCHARGE

PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	1.012				1
PROD-TONS/DAY	120				1
GAL/TON	8,400				1
TEMP-DEG F	86.3	82-90			1
pH		6.2-8.4			1
CONDUCTANCE	911	337-2,625			1
SO4, mg/l	133	109-168	1.129	3.73	1
ACIDITY-CACO3, mg/l	4.0	0.0-28	33.7	0.112	1
ALKALINITY, mg/l	100	148-224	846	2.82	1
HEXANE EXTR., mg/l	25.4	19.3-25.4	214	0.713	1

TABLE 8 - ACETIC ACID WASTEWATER DISCHARGE
PRIMARY DISTILLATION & CONCENTRATION

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	42				1
PROD-TONS/DAY	1250				1
GAL/TON	33,600				1
TEMP-DEG F	75.6	71.8-79.6			1
pH	7.4	6.8-7.9			1
CONDUCTANCE	3.02	234-412			1
NO2+NO3-N	1.13	0.12-3.65	395	0.31	1
KJEL-N	0.56	0.19-5.59	196	0.15	1
NH3-N	0.22	0.0-0.96	76.9	0.06	1
PO4-P	0.03	0.0-8.67	105	0.08	1
SO4	8.9	8.3-9.4	3110	2.48	1
ACIDITY-CACO3	4.06	1.49-5.64	1422	1.13	1
ALK-CACO3	39.7	3.74-47	13,800	11.1	1
TOT. SOLIDS	91	42-144	31,800	25.4	1
SUSP. SOLIDS	3.58	0.014-14.9	1250	1.00	1
DISS. SOLIDS	124	115-167	43,300	34.7	1
BOD	6.3		2200	1.76	1
COD	11.0	0.1-33.2	3844	3.07	1
TOC	3.49	0.61-14.6	1219	0.97	1
ACETIC ACID	1.17	1.16-3.15	409	0.32	1

*Values are mg/l unless otherwise indicated.

TABLE 9 - ACETIC ANHYDRIDE
CRUDE PRODUCT AND REFINING WASTEWATER DISCHARGE

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	4.7				1
PROD-TONS/DAY	360				1
GAL/TON	13,000				1
TEMP-DEG F	71.9	70.2-74.4			1
pH	7.4	5.7-8.1			1
CONDUCTANCE	246	155-955			1
NO2+NO3-N	1.04	0.5-1.4	40.6	0.112	1
KJEL-N	0.5	0.5-54.4	19.5	0.054	1
PO4-P	0.25	0.1-251	9.77	0.027	1
SO4	22.0	13.9-55.2	860	2.39	1
ACIDITY-CACO3	4.29	2.7-140	168	0.465	1
ALK-CACO3	80	56-83	3127	8.68	1
TOT. SOLIDS	84	12.1-570	3283	9.12	1
SUSP. SOLIDS	4.67	0.0-13.8	182	0.507	1
DISS. SOLIDS	73	26-176	2850	7.92	1
BOD	0.8	0.7-5.4	31.3	0.086	1
COD	12.8	10.4-25.1	500	1.39	1
TOC	6.02	3.02-14.6	235	0.653	1
ACETIC ACID	2.0	2.0-5.0	78.2	0.217	1

*Values are mg/l unless otherwise noted.

15. Nitrocellulose Production

a. High waste volume results from successive washing of products to remove residual acids and unstable by-products (about 2/3 of total waste volume).

b. Waste flow is to the acid neutralization plant, and includes acid wash water and boiling tub wash water, having the following characteristics: extremely low pH average of 1.4 (range 0.4-3.3); high sulfate average of 2600 mg/l (range 75-5100); high nitrate-N average of 700 mg/l (range 100-1350); high COD average of 185 mg/l (range 80-650); high nitrocellulose content average of 188 mg/l.

c. The high value of COD is likely due to dissolved and suspended cellulose and nitrocellulose in the waste water. High solids values are the results of pulping and blending of NC. NC fines are partially removed along with waste water (white water) in the final centrifuge to separate NC from the waste.

d. Some characteristics of the white water are: extremely high NC average of 477 mg/l; high COD average of 534 mg/l (range 284-784); high TS average of 794 mg/l (range 442-1462); high SS average of 518 mg/l (range 343-828); nearly neutral pH average of 7.73 (range 7.4-8.2).

e. The pH values vary from extremely acidic in the initial wash water to neutral or slightly basic in the final washes.

f. Suspended solids in the waste water can be assumed to at least approximate NC fines being lost. NC fines are recovered and recycled back for use as "pit cotton" when making up blends which contain both high grade and low grade NC. This results in lower SS values in the final effluent.

g. The still bottoms from organic solvent recovery have high BOD and COD due to organic solvent in the waste, which also results in high alkalinity. Total solids are approximately 50% SS and 50% DS, since boiling had removed most of the volatile solids. Tables 10 and 11 summarize available data.

16. Nitroglycerin Production

a. The pH of wastewater from NG manufacture ranges from acidic for the first wash (sour wash) after nitration, to alkaline for the subsequent washes with sodium carbonate.

b. These wash waters are usually saturated with NG, at up to more than 2500 mg/l. The neutralizing wash yields high sodium level (more than 10,000 mg/l), which gives rise to high solids content.

c. Residual nitro- and dinitroglycerin and glycol show up as oil and grease, and also cause high BOD and COD.

d. The nitrating acids result in high nitrate and sulfate levels. Sour water, final wash and spent acid characterizations are given in Table 12.

e. Table 13 summarizes available data.

17. TNT Production

a. Waste water sources include cooling water and process water. Process waste water is generated primarily in the steps of washing and purifying of crude TNT, and reclamation of spent nitrating acids. The following discussion does not include the acid reclamation process.

b. Yellow water is the result of the first washing to remove acids. Yellow water contains nitric and sulfuric acids as well as dissolved TNT. Most yellow water is recycled in the continuous TNT process.

c. Red water is the waste from the purification step, utilizing washing with sellite. Pink water is produced in the final washing of purified TNT. It contains mainly TNT, and other nitrobodies. Pink water is also a principal effluent from spills and building and equipment washdown in the LAP operations. One plant cited utilizes 4.5 MGD out of 5.15 MGD for cooling water, and about 0.65 MGD for process water. Cooling water flow thus represents 87% of the total process flow.

d. The major pollutants include nitrotoluenes, nitrates, sulfates, acidity, sodium sulfite, sodium nitrate, sodium bisulfite and sodium trinitromethane sulfonate. Table 14 summarizes waste characteristics.

18. RDX - HMX

a. RDX and HMX are manufactured only at Holston AAP. Current production averages 2.64 tons/day HMX and 166 tons/day RDX or about 169 tons/day combined. The wastewater flows average 30.3 MGD, of which about 80% is utilized for cooling water in the product recrystallization from cyclohexanone. Other sources of wastewater include process and cooling water for ammonia recovery, nitration process, slurry processing, recrystallization, grinding and dewatering, mixing specific product compounds and loading and packing operations.

b. In the explosive production areas, cooling waters and process waters are segregated. Process waste water contains amounts of solubilized RDX and HMX.

c. One of the primary end products of RDX at Holston AAP is a formulation of explosives, "Composition B," which contains RDX and TNT. Thus Table 15 also considers Composition B as a product of interest.

TABLE 10 - NITROCELLULOSE PRODUCTION WASTEWATER DISCHARGE

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	5.01	2.96-7.07			2
PROD-TONS/DAY	50	29-70			2
GAL/TON	101,100	45,000-157,000			2
pH	1.2	0.9-12.4			2
NO2-NO3-N	513	190-648.1	12,600	272	2
KJEL-N	3.52	0.19-6.84	86.8	1.33	1
NH3-N	0.78	0.25-2.05	25.05	0.45	2
SO4	501		29,200	649	1
ACIDITY-CACO3	0.07		1.76	0.027	1
ALK-CACO3	2.83		69.9	1.07	1
TOT. SOLIDS	5031	56.3-10,000	124,000	5676	2
SUSP. SOLIDS	240	68.1-312	13,300	292	2
DISS. SOLIDS	4966	47.8-9880	123,000	2474	2
VOL. SOLIDS	1948	7.9-3889	48,100	731	1
BOD	1.17		29.0	0.42	1

*mg/l unless otherwise noted.

TABLE 11 - NITROCELLULOSE
SOLVENT RECOVERY, STILL BOTTOMS WASTEWATER DISCHARGE

PARAMETER	CONCENTRATION*		LB/DAY	LB/TON	NR. OF PLANTS
	MEAN	RANGE			
FLOW-MGD	0.0148	0.00864-0.021			2
PROD-TONS/DAY	19.92	19.14-20.71			2
GAL/TON	722				
pH	7.2	7.1-7.4			2
NO2-NO3-N	3.0		0.527	0.004	1
KJEL-N	2.0		0.351	0.002	1
ACIDITY-CACO3	7.2	7.0-7.33	1.03	0.006	2
ALK-CACO3	283	246-372	38.4	0.266	2
TOT. SOLIDS	1535	49.7-5146	114.0	0.79	2
SUSP. SOLIDS	747	7.17-2545	52.2	0.364	2
DISS. SOLIDS	810	34.7-2695	60.86	33.7	2
VOL. SOLIDS	39.7	25.0-68.0	6.97	0.048	1
BOD	118	44.7-295	11.7	0.083	2
COD	104		18.3	0.126	1

*mg/l unless otherwise noted.

TABLE 12

	Sour Water	Final Wash with $NaCO_3$	Spent Acids
pH	1.72	10	
BOD mg/l	1		
COD	63	1,130	22
NO_3-N	114.1	520	433
TS	264	3217	
SS	5	3027	
sulfate	414	5	760

TABLE 13 - NITROGLYCERIN PRODUCTION WASTEWATER DISCHARGE

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	0.041	0.010-0.110			5
PROD-TONS/DAY	11.84	9.82-12.9			5
GAL/TON	3473	752-8590			5
pH	3.0	2.7-10			4
TOT. ORG N	242	0.0-484	4.44	0.99	2
NO2-NO3-N	5565	345-12500	744	40.0	3
KJEL-N	23.0	2.88-43.2	0.76	0.05	3
NH3-N	12.1	0.0-33.7	0.43	0.04	4
SO4	3154	208-6996	107.1	6.68	4
ACIDITY-CACO3	0.01	0.0-0.02	0.006	0.001	1
ALK-CACO3	2023		1080	110	1
TOT. SOLIDS	49,165	2110-81,527	5307	286	4
SUSP. SOLIDS	668	46-1894	11.9	0.96	4
DISS. SOLIDS	5761		3075	313.5	1
BOD	26.0	167-352	32.3	1.73	3
COD	2260	709-3518	234	13.0	4
OIL & GREASE	313		10.96	0.61	1
SODIUM	13323	11777-14879	1447	77.7	2
NG	4104	314-12,700	281	15	3

*mg/l unless otherwise noted.

TABLE 14 - TNT PRODUCTION WASTEWATER DISCHARGE

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	6.11	2.63-9.60			2**
PROD-TONS/DAY	223	50-300			4
GAL/TON	27,400				
TEMP-DEG F	84.5	78-90			2
pH	5.9	5.6-7.6			2
NO2-NO3-N	13.8	11.7-15.9	701	3.14	2
KJEL-N	3.90	1.41-6.40	198	0.852	2
SO4	367	230-496	18,600	83.6	2
ACIDITY-CACO3	69.6	16.2-123	3535	15.8	2
ALK-CACO3	97.4	79.8-115	4949	22.2	2
TOT. SOLIDS	761	480-1043	38700	173.4	2
SUSP. SOLIDS	42.2	15.5-69.0	2144	9.61	2
DISS. SOLIDS	710	410-1011	36,075	162	2
VOL. SOLIDS	446		22,600	102	1
COD	28.3		1438	6.45	1
TOC	143		7266	32.6	1
SULFIDE	5.96		303	1.36	1

*mg/l unless otherwise noted.

**of the 2 plants summarized, one was batch process - 302 tons/day, the other continuous - 145 tons/day.

TABLE 15 - PRODUCTION OF RDX, HMX, AND COMPOSITION B, WASTEWATER DISCHARGE

	CONCENTRATION*				
PARAMETER	MEAN	RANGE	LB/DAY	LB/TON	NR. OF PLANTS
FLOW-MGD	30.3				1
PROD-TONS/DAY	275				1
GAL/TON	110,200				1
TEMP-DEG F	60	50-72			1
pH	7.3	7.0-8.3			1
NO2-NO3-N	0.028		7.28	0.026	1
KJEL-N	0.037		9.56	0.035	1
NH3-N	0.015		4.02	0.015	1
TOT. SOLIDS	14.0		3520	12.8	1
DISS. SOLIDS	14.2		3570	13.0	1
BOD	30.2		7620	27.7	1
COD	69.0		17,400	63.3	1
TOC	2.53		638	2.32	1
INORG C	0.607		153	0.556	1
RDX	0.492		124	0.451	1
HMX	0.179		45.2	0.164	1
ACETIC ACID	6.75		1700	6.18	1
HEXAMINE	0.119		30	0.109	1
TNT	0.324		81.8	0.297	1
SOLVENTS**	4.88		1230	4.47	1

*mg/l unless otherwise noted.
**acetone, cyclohexane, toluene, butanol.

SECTION III - ACIDS

19. ACETIC ANHYDRIDE MANUFACTURE

a. Process Description

Acetic anhydride ($(CH_3CO)_2O$) is manufactured at HAAP. The manufacturing process involves two steps, the first of which is carried out in Buildings 7 and 20 (Area A) and the second in Buildings 6 and 6A (also in Area A). For a detailed process description the reader is referred to Chapter IV of this report.

Crude acetic anhydride is manufactured in Buildings 7 and 20. To obtain this product, glacial acetic acid vapor is catalytically cracked and the cracking products are absorbed in glacial acetic acid. The crude anhydride is then fed to Buildings 6 and 6A where it undergoes two distinct operations -- acetic anhydride refining and concentration of recovered acetic acid.

b. Water Use and Wastewater Volume

(1) Water Use. Water use figures were not available. However, because cooling and process waters are discharged jointly, wastewater volumes may be used as an approximation of the necessary feed volumes.

(2) Distribution of Wastewater Volumes. Table 16 summarizes the wastewater volumes generated in producing acetic anhydride. Source data for Table 16 can be found in Tables I.A.1 through I.A.3 (Appendix I).

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Wastewaters from the crude acetic anhydride manufacturing process are reported (4a) to contain acetic anhydride, acetic acid, acetaldehyde, acetonitrile, methyl acetate, methyl nitrate, ethanol, methanol, ethyl acetate, propanol, and propyl acetate. The various waste streams are mixed with cooling waters needed in the anhydride manufacturing and then discharged to the South Fork of the Holston River.

Wastewaters from the acetic anhydride refinery area include cooling and condenser waters and process waters plus a portion of the sludges from the refining and azeotropic distillation columns (acetic acid concentration). These wastes are discharged to the industrial sewer.

Results of analyses of the major wastewater discharges from Building 7 are presented in Tables I .A.1 and I .A.2. Similar results for Buildings 6 and 6A appear in Table I .A.3 (Appendix I). Note that the constituent(s) responsible for the dissolved solids content are not defined by this data. No treatment is currently being provided for any of these wastes.

Table 17 lists the calculated overall discharges in both lb/day and lb/ton of final product for the entire process carried out in Buildings 6, 6A, and 7.

d. The Effects of Process Change on the Wastewaters

The following actions have been proposed as part of the pollution abatement program for HAAP Area A.

Installment of flash columns in Building 6 is expected to reduce solvent concentrations in wastewater by 50 percent and improve propyl acetate recovery. The possible substitution of a surface condenser for barometric condensers in Building 7 is expected to reduce water pollution. However, the mechanism whereby this is to be accomplished and the specific pollutants to be eliminated or reduced have not been detailed (4a). Alternate means of handling and disposing of ball mill and sludge heater sludges generated in Buildings 6 and 6A are being sought. These sludges are a likely major waste source that should be handled and disposed of in slurry or semi-solids form. Heavy metal and acidity problems are apparently associated with the disposal of these waters.

Although the presence of trace organics has been discussed in a qualitative manner, the quantitative aspects of this problem need to be defined. In other words, data of this sort has to be generated.

Segregation of cooling and process waters in the future will, of course, increase discharge concentrations in process wastewater. Overall discharge loads (lbs/day and lbs/ton of product) should, however, remain the same except as noted above.

e. Data Limitations

Water usage data was not available. Such data is of considerable aid in identifying process efficiency. In addition, it allows for an assignment of significance of the process based on water needs and for verification of wastewater volumes and subsequent discharge loads. Analysis of process feedwaters would also prove useful in calculating discharge loads.

The constituents responsible for the dissolved solids content of the wastewater streams were not identified. Planning for future handling of these wastes requires that the source(s) of dissolved solids be identified.

TABLE 16
WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF ACETIC ANHYDRIDE AT HAAP

	Crude Anhydride Production	Acetic Anhydride Refining and Acetic Acid Concentration	Overall
MGD	7.39	1.15	8.54
Gal per Ton of Final Product	23,500[1]	3,190[2]	23,700[2]

[1] 630,000 lb/day crude acetic anhydride
[2] 720,000 lb/day refined acetic anhydride

TABLE 17

OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF ACETIC ANHYDRIDE AT HAAP

	Discharge (lb/day)	Discharge (lb/ton of product*)
TKN/N	> 95.8	>0.266
o-PO_4/P	326	0.906
Acidity/$CaCO_3$	756	2.10
Total Solids	5,130	14.3
Suspended Solids	190	0.53
Total Dissolved Solids	3,147	8.74
SO_4	102	0.294
COD	11.5	0.032
TOC	69	0.19

*Refined acetic anhydride produced

20. CONCENTRATED ACETIC ACID MANUFACTURE

a. Process Description

Acetic acid (CH_3COOH) is recovered from the manufacture of RDX/HMX at HAAP, concentrated, and reused in the nitration of hexamethylenetetramine (hexamine) to form RDX and HMX and in the production of acetic anhydride.

A hypothetical charge of 100 pounds of chemicals used in the production of RDX ("Bachman Method") requires 15.0 pounds of acetic acid. HMX requires the same reactants but in different proportions. Again considering a hypothetical 100 pound reactant charge, about 18 pounds of acetic acid is required to produce HMX (2c).

When the heated reaction mixture used in the nitration step has cooled and most of the crude RDX or HMX has precipitated, nearly all of the supernatant liquid is drawn off by vacuum and transferred to a recovery building (primary distillation building). Here the nitric acid content is neutralized with sodium hydroxide slurry. About 80 percent of the resulting solution is then evaporated. Acetic acid is recovered from the vapors and sent to Area A for concentration. As it leaves the primary distillation buildings, the acid-water solution is approximately 60 percent acetic acid. Upon final concentration in Area A the solution is 99+ percent acetic acid.

b. Water Use and Wastewater Volume

(1) Water Use. Water use figures were not available for either the primary distillation (recovery) or acetic acid concentration processes. However, comparison of the total process waste flow from acetic acid concentration, 15.8 mgd (1d(2)), to the average raw water intake for Area A, 48.7 mgd (4a), indicates that a significant proportion of the total water use in HAAP Area A is used in this step. In a similar manner, comparison of the total flow from the primary distillation step, 26.0 mgd (1d(2)), to the total

water consumption for Area B, 84.4 mgd (1d(2)), indicates that this step also consumes a sizeable fraction of the total water used in its respective area.

(2) Distribution of Wastewater Volumes. There are essentially two steps involved in the production of concentrated acetic acid at HAAP. The first step involves the recovery of acetic acid from the manufacture of RDX or HMX (and eventually composition B) in Area B. In the E Buildings in a typical Area B production line, spent acid is removed from the RDX product, diluted with product wash water and transferred through glass lines to a collection tank where it awaits transfer to the B line. This weak acid filtrate contains some dissolved explosives. At primary distillation (B line) nitric acid is neutralized and most of the acetic acid is distilled off as a 60 percent solution in water and pumped to Area A. Explosives are recovered and returned to the E Buildings, and the remaining sludge is treated with caustic (sodium hydroxide) and converted to sodium nitrate to be sold as a commercial fertilizer.

Total wastewater generated in this recovery step is 26.0 mgd. This is an estimated figure based on flow measurements made on the principal effluent from Building B-11 (1d(2)) and extrapolation of this figure to include all the distillation units in operation. Production averages 1,500,000 pounds 60 percent acetic acid per day (1d(2)).

The distillation facilities in Building 2 Area A concentrate the acetic acid returned from the primary distillation line in the explosives manufacturing area, Area B. To achieve the separation of water from acetic acid within a finite distillation column size, azeotropic distillation techniques are used. The reader is referred to Chapter IV of this report for a more detailed description of this process.

Total wastewater flow from the concentration step is 16.0 mgd (1d(2)). There are several outfalls from Building 2; however, each outfall discharges to the main waste stream from Area A. The total wastewater flow cited above is the sum of these individual process streams. Production at the time of flow measurements averaged 1,600,000 pounds of concentrated acetic acid per day (1d(2)).

Table 18 summarizes the wastewater volumes generated in the production of concentrated acetic acid. Source data for Table 18 can be found in Tables I.D.1 through I.D.3 (Appendix I).

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Wastewaters from acetic acid concentrations, Area A HAAP, include cooling water, spent process water, and sludges. These wastes are reported (4a) to contain nitromethane, methyl nitrate, acetic acid, n-propyl acetate, nitric acid, and trace amounts of explosives. It is likely, however, that the concentration of these organic constituents is low since they were not detected in the main outfall from Area A which receives these wastes (4b).

In the course of the azeotropic distillation, as a result of the character of the feed to the Building 2 distillation units, a certain amount of solids buildup occurs in the base heater or reboiler section of the column. To maintain approximately one percent solids concentration in the reboiler, a small bleed stream is removed from the reboiler approximately once every hour or once every two hours of operation of the still. This bleed stream is sent to a storage tank until sufficient volume (approximately 8,100 gallons) is accumulated to charge a sludge heater. The sludge heater operation is simply an extension of the distillation process in which as much acetic acid as is economically recoverable is removed from the solids-bearing liquid. Elevated temperature and vacuum are applied to the contents of the sludge heater, and the acetic acid vapor is taken overhead until the concentration of solids in the sludge heater reaches 18 percent. At this point in time, water is added to the contents of the sludge heater, and distillation is continued until the overhead concentration of acetic acid vapor is less than or equal to two percent. At this point, the contents of the sludge heater are discharged to the sewer. The contents of sludge heaters are discharged approximately twice each week. Recently, attention has been called to the fact that the sludge heater sludge, as discharged to the sewer, contains heavy metals. Analyses of these sludges on several occasions have yielded high concentrations of chromium, copper, iron, and manganese. The reported source of these heavy metals is the corrosive destruction of the distillation columns in Building 2.

Chromium and copper have been detected at sub-part-per-million levels in the main effluent from Area A (5a). However, to what extent this is a result of the discharge of sludge heater sludges is unknown.

Results of a USAEHA study (1d(2)) monitoring the two major wastewater discharges from the acetic acid concentration process are reported in Tables I.D.1 and I.D.2 (Appendix I). Unfortunately, the constituent(s) responsible for the high dissolved solids content (6700 lbs/day) are not identifiable from the data. The low COD/BOD ratio, $<$ 1.33 in the case of the 42-inch outfall and approximately 2.0 in the case of the 15-inch outfall, is an indicator of low-level toxicity and readily oxidizable nature of the substrate.

A pilot aeration pond was set up to receive wastes from the stripping operation carried out in Building 2, Area A, HAAP. This operation removes (recovers) propyl acetate and other low boilers from the water phase resulting from azeotropic distillation to concentrate acetic acid. After solvent recovery, part of the effluent water was diverted to the pilot aeration pond. This diverted waste stream was found to contain four percent organics, chief among these being formaldehyde. Chromium, copper, and lead were not detected (5a, 15a).

USAEHA data (1d(2)) for the primary distillation process (acetic acid recovery) carried on in Building B-11, HAAP Area B are presented in Table I.D.3 (Appendix I). Again the ion balance is incomplete, and the data does not identify the item(s) responsible for the dissolved solids content (10,200 lbs/day) of the waste. The TRW report (3f) cites a somewhat higher ammonia concentration (5 ppm) than reported here. Whether or not this value has been corrected for background is not stated.

Currently these wastes receive no treatment other than that they are routed through settling basins prior to discharge into the industrial sewer. When the sludge is cleaned from these basins by dippers, however, fines are often resuspended (1d(2)).

Table 19 lists the calculated overall discharges in both lbs/day and lb/ton of final product for the entire process (acetic acid recovery and acetic acid concentration).

d. The Effects of Process Change on the Wastewaters

Installation of flash columns in Buildings 2 and 6 (HAAP Area A) is expected to reduce solvent pollution by 50 percent (4a). In addition, modernization plans call for replacement of the 316 stainless steel columns currently in use in the sludge heater (Building 2). The replacement columns will be constructed with an alloy of the Hastelloy group and should alleviate the heavy metal problem associated with the sludge heater wastes (see Para. 20.c. above). In the interim, CERL personnel have recommended that sludge heater sludges be discharged in proportion to other wastes generated in Building 2 in order to reduce the potential for major toxic effects (1d(2)).

Segregation of uncontaminated cooling water from process water will increase discharge concentrations. Ammonia concentration in wastewater from primary distillation (Building B-11, HAAP Area B) is reported to be on the order of 900 ppm prior to mixing with cooling water. Ammonia stripping has been suggested for ammonia-rich waste streams (3f).

e. Data Limitations

Production of concentrated acetic acid apparently results in the discharge of a particularly high dissolved solids load (see Tables I.D.1 through I.D.3, Appendix I). The constituent(s) responsible for this load have not been identified, and it is essential to future treatment planning that they should be.

Water usage figures were not available.

TABLE 18
WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF CONCENTRATED ACETIC ACID AT HAAP

	Primary Distillation	Acetic Acid Concentration	Overall
MGD	26.0	16.0	42.0
gal/ton of Final Product	34,700[1]	20,000[2]	52,500

[1] 1,500,000 lb/day 60 percent acetic acid
[2] 1,600,000 lb/day 99+ percent acetic acid

TABLE 19

OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF CONCENTRATED ACETIC ACID AT HAAP

Item	Discharge (lb/day)	Discharge (lb/ton of product*)
TKN/N	138	0.172
NH_3/N	$\geq$ 20.4	$\geq$ 0.025
$NO_2 + NO_3$/N	127	0.159
o-PO_4/P	87	0.11
Acidity/$CaCO_3$	140	0.175
Total Solids	17,480	21.9
Suspended Solids	460	0.575
Dissolved Solids	16,900	21.1
COD	12,000	15.0
TOC	3,710	4.64
BOD	$\geq$ 8,569	$\geq$ 10.7
SO_4	$\geq$ 64	$\geq$ 0.08
Acetic Acid	$\geq$ 2.7	$\geq$ 0.003

*1,600,000 lb/day (800 ton/day) 99+ percent acetic acid

21. WEAK NITRIC ACID (HNO_3) PRODUCTION (AOP)*

a. Process Description

There are two ammonia oxidation processes at HAAP. Currently, only one of these, the Dupont Process (Bldg 302-B), is in use. The Hercules Process (Bldg 302) is not presently being employed. For further details of both processes refer to Chapter IV of this report.

b. Water Use and Wastewater Volumes

(1) **Water Use.** Water usage data was not available.

(2) **Distribution of Wastewater Volumes.** Refer to Tables I.S.1 through I.S.4 for flow rates of individual waste streams. Overall flow from this operation is 9.22 mgd (46,100 gal per ton of product) at a production rate of 400,000 lb/day 61 percent HNO_3 (as 100 percent HNO_3).

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Wastewater characterization data is presented in Tables I.S.1 through I.S.4. This data is summarized in Table 20. Dissolved solids discharges appear to present a problem. However, the nature of these materials is not apparent from the given data.

d. Effects of Process Change on the Wastewaters

A new 300 ton/day ammonia oxidation plant, PEMA project number 570-2072, is scheduled for completion in 1974. No predictions as to the quantity and character of the wastewaters is available. The six Hercules units will be used only to meet peak requirements (1d(2)).

e. Data Limitations

AOP wastewaters at HAAP appear to have been well characterized; however, data from similar waste streams generated at BAAP, InAAP, RAAP, SAAP, VAAP, AAAP, and NAAP was not available at the time this report was written.

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*At JAAP, weak (60 percent) HNO_3 is produced by the ammonia oxidation process (AOP). This dilute acid and spent acids recovered from the nitration processes (TNT manufacture) are utilized to produce strong (98 percent) nitric acid by the nitric acid concentration (NAC) process. Dilute sulfuric acid yielded by the NAC process and explosive manufacturing process is utilized to produce strong sulfuric acid (93 percent) by the sulfuric concentration (SAC) process. It was not possible, however, to separate wastestreams from AOP, NAC, and NAC operations. Wastewater characterization data for the combined effluent from all three processes is presented in Tables I.S.5 and I.S.6 (3f).

Joliet AAP has the manufacturing capability to meet mobilization requirements for TNT, DNT, and tetryl, but not for the required nitric acid and oleum quantities. The acid manufacturing facilities are old and outdated. They could probably be kept operating indefinitely by increasing maintenance budgets, but because of their lags and the pollution problems created, they will be replaced with modern processes and equipment. Modernization of the acid facilities is scheduled for completion in 1976 and will include replacement of weak nitric acid facilities with updated AOP, replacement of the AOP/NAC nitric acid concentration process with the direct strong acid (DSNA) process, replacement of the sulfuric acid concentration process by the sulfuric acid regeneration (SAR) process (used to produce oleum directly as end product) (3f).

TABLE 20

CALCULATED OVERALL DISCHARGE RESULTING FROM THE PRODUCTION OF WEAK NITRIC ACID (1d(2))

Item	Discharge (lb/day)	Discharge (lb/ton of product*)
NH_3/N	2.7	.014
$NO_2 + NO_3/N$	385	1.92
TKN/N	3.67	.018
Acidity/$CaCO_3$	25.0	.125
Alkalinity/$CaCO_3$	14.8	.074
Total Solids	6,840	34.2
Suspended Solids	168	.84
Dissolved Solids	6,540	32.7
COD	797	3.98
TOC	35	.175
BOD	$<$ 314	1.57

*200 ton/day 61 percent HNO_3 (as 100 percent HNO_3) produced

22. CONCENTRATED NITRIC ACID MANUFACTURE*

a. Process Description

Although concentrated nitric acid is manufactured at VAAP, RAAP, BAAP, InAAP, NAAP, AND JAAP, data concerning this process was not available for these plants. Nitric acid is concentrated at HAAP (Buildings 303-B and 334, Area B) using the magnesium nitrate process. The nitric acid concentration (NAC) units concentrate the weak acid manufactured in the ammonia oxidation area by removing water from the acid. Magnesium nitrate has a chemical attraction for water and can be used in the ternary system, magnesium nitrate-nitric acid-water, to remove water from the acid by extractive distillation.

Weak (61 percent) nitric acid and concentrated (72 percent) magnesium nitrate solution are fed to the top of a three-stage stripping column together with the intermediate (80-90 percent) nitric acid from the base of the rectifying column. Overhead vapors from the stripping column are condensed and then divided into reflux and product streams. The product portion (99 percent nitric acid) is further cooled in cascade coolers. The uncondensed overhead vapors from the strong nitric acid condensers are led to a rectifying column and scrubbed with water before being vented to the atmosphere. The bottoms from the stripping column, which have been denitrated to less than 0.1 percent nitric acid, contain roughly 60 percent magnesium nitrate. This solution is first concentrated to approximately 64 percent $Mg(NO_3)_2$ in a steam heated reboiler (base heater) which also supplies the heat for the stripping and rectifying columns. Further concentration to the original feed strength of 72 percent $Mg(NO_3)_2$ is carried out in a vacuum evaporator. Water is removed in the vacuum evaporator and discharged to the sewer (1d(2)).

Magnesium nitrate is not consumed in the NAC process. Fresh magnesium nitrate is added only to replace losses due to leaks and equip-

Joliet AAP has the manufacturing capability to meet mobilization requirements for TNT, DNT, and tetryl, but not for the required nitric acid and oleum quantities. The acid manufacturing facilities are old and outdated. They could probably be kept operating indefinitely by increasing maintenance budgets, but because of their age and the pollution problems created, they will be replaced with modern processes and equipment. Modernization of the acid facilities is scheduled for completion in 1976 and will include replacement of weak nitric acid facilities with updated AOP, replacement of the AOP/NAC nitric acid concentration process with the direct strong nitric acid (DSNA) process, replacement of the sulfuric acid concentration (SAR) process (used to produce oleum directly as end product (3f).

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*At JAAP, weak (60 percent) HNO_3 is produced by the ammonia oxidation process (AOP). This dilute acid and spent acids recovered from the nitration processes (TNT manufacture) are utilized to produce strong (98 percent) nitric acid by the nitric acid concentration (NAC) process. Dilute sulfuric acid yielded by the NAC process and explosive manufacturing process is utilized to produce strong sulfuric acid (93 percent) by the sulfuric concentration (SAC) process. It was not possible, however, to separate wastestreams from AOP, NAC, and SAC operations. Wastewater characterization data for the combined effluent from all three processes is presented in Tables I.E.2 and I.E.3 (3f).

ment cleaning. A concentrated (72%) solution of this material will freeze unless kept above 100°C. The magnesium nitrate content of each unit is roughly 20,000 pounds (as 72% magnesium nitrate). To keep from wasting this amount when a unit goes down for repairs, the solution is slowly diluted and cooled and then sent to settling tanks (numbered 334-14 and 334-15) located adjacent to the magnesium nitrate receiving tank. Solids that settle out in these tanks are washed to the drainage ditch at present (1d(2)).

Further details of the nitric acid concentration process can be found in Chapter IV of this report.

b. Water Use and Wastewater Volume

(1) Water Use. Water use figures for nitric acid concentration were not available. At a production rate of 9,210,000 lb per month (approximately 307,000 lb/day) nitric acid (as 100 percent acid), the weak acid feed rate is approximately 33.6 gpm (48,000 gpd) (1d(2)).

(2) Wastewater Distribution. An estimated wastewater discharge of 5.0 mgd arises from nitric acid concentration. In terms of production of 99 percent nitric acid this constitutes an effluent of 32,500 gal per ton of final product. Table I.E.1 gives further details of the wastewater flow. Liquid wastes from the ammonia oxidation step (Building 302-B, HAAP Area B) are intermingled with other measured NAC waste streams and prevent further association of waste volume with specific process subdivisions.

c. Qualitative and Quantitative Aspects of the Liquid Wastes

It has been reported (4a) that wastewaters from the concentrating process are essentially all cooling waters. In establishing the discharges reported in Table 21 from data gathered in the 1971 USAEHA study (1d(2)) the assumption has therefore been made that all pollutants measured in streams containing liquid wastes from both ammonia oxidation and nitric acid concentration are due solely to the ammonia oxidation process. It is acknowledged that this is a (somewhat erroneous) oversimplification. However, it is also the only step that can be taken to allow some degree of quantification and qualification of the wastewater character based on existing data.

As mentioned above, overall discharges from NAC (HAAP Area B) are cited in Table 21. It is immediately obvious that this data does not account for the high measured value of dissolved solids.

No treatment is currently being provided for these wastes, and they are being discharged directly to the Holston River.

d. The Effects of Process Change on the Wastewaters

There appears to be little planned in the way of process change or modification (including pollution abatement) that will affect the nature of the watewaters resulting from the production of concentrated nitric acid.

e. Data Limitations

Existing data does not allow identification of the constituent(s) comprising the high dissolved solids content in the waste streams from this process. Dissolved solids ranged from 473 to 866 ppm, and summation of the other dissolved materials does not even approach these values.

TABLE 21

OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF CONCENTRATED NITRIC ACID AT HAAP

Item	Discharge (lb/day)	Discharge (lb/ton of product*)
$NO_2 + NO_3/N$	423	2.75
Acidity (as $CaCO_3$)	94	0.61
Total Solids	5650	36.6
Suspended Solids	94	0.61
Dissolved Solids	5560	36.1
COD	264	1.71
BOD	<75**	<0.49**

* 99% HNO_3 produced

**No correction for filtered raw water - Area B, Holston AAP

23. CONCENTRATED SULFURIC ACID PRODUCTION

Sulfuric acid concentration (SAC) processes are carried out at BAAP, InAAP, VAAP, RAAP, and NAAP (3e). However, insufficient data exist to accurately characterize the liquid wastes. A discussion incorporating what information is available is presented below.

At RAAP, no pollutants are reported to arise from SAC operations. Currently there are no existing SAC water pollution abatement practices at Radford, and there are none proposed (3f).

At InAAP, lime is added to the acid waste sewers to control pH (1f(1)).

A 1971 USAEHA study (1a(1)) lists sulfuric acid concentration as one of the six main contributors to water pollution at BAAP. The primary pollutants from SAC operations are described as acid wastes. These wastes are currently controlled by lime neutralization. Recently, relocation of pH sensors has resulted in better control of pH adjustments in the acid neutralization area. A new 350 ton per day OV/SAR plant was constructed in 1972; however, the effects this may have had on wastes from the SAC process are unknown.

At VAAP, wastewaters from the SAC process are listed as a major source of potential pollution (1r(1)). These wastes are neutralized with lime prior to discharge to Waconda Bay.

NAAP has constructed a new sulfuric acid regeneration facility in support of TNT manufacture. Wastewater flow from this facility is generated in the purification area where excess water from the process is condensed out and purged from the system as a weak H_2SO_4 solution. Approximately 89,600 lb/hr (258,000 gpd) 2.5 percent H_2SO_4 solution results (3f).

In summary, it may be stated that the wastestreams resulting from SAC appear to present largely pH problems which are currently being handled by lime neutralization.

24. OLEUM PRODUCTION

a. Process Description

The reader is referred to Chapter IV of this report for a more detailed process description.

Oleum is sulfuric acid containing an excess of free sulfur trioxide. Oleum (40%) is produced at BAAP by the catalytic oxidation of elemental sulfur and absorption in a multiple phase absorber with water and recycled sulfuric-nitric acid mixture. Raw water is used for cooling purposes and treated water for absorption. The only liquid waste generated from this area during normal operations is one-pass cooling water. Occasional process upsets and cleanup operations allow oleum or sulfuric acid to enter the waste streams. These upsets are not a common occurrence. All industrial waste from this area drains to the oleum area waste pond, a sand bottom pond with no discharge to surface waters. All waste is disposed of by evaporation or percolation (1a(2)).

At JAAP, a recent USAEHA study (1g(3)) found one of three oleum production units in operation. This unit produced 40% oleum (109% H_2SO_4) and continuously mixed it with an antifreeze (HNO_3). Sulfur is first melted, then burned, producing SO_3 gas which passes through filters to remove dirt. The gas is cooled to the proper temperature for entering the absorption towers. Acid towers are provided for drying the air and absorbing SO_3 to proper strengths. All towers are equipped with pumps for continuously circulating acid. Each tower has its own cooling system, piping, and transfer lines. Equipment is provided to continuously mix the oleum leaving the absorption towers with antifreeze (1g(3)).

b. Water Use and Wastewater Volume

(1) Water Use. RAAP reports using 3,500,000 gpd in their old oleum facilities. No associated production figures were available. However, new facilities employing recycle are scheduled (6a). At JAAP, no water usage figures were available.

(2) Wastewater Flows. The liquid waste discharged from the oleum production area at BAAP is one pass cooling water, however, there are occasional process upsets and waste streams. All industrial wastes from this area are drained to the oleum area waste pond, a sand bottom pond with no discharge to surface waters. All waste is disposed of by evaporation or percolation. The presence of lower biological and animal forms in nearby areas indicates that wastewater from this area does not constitute a source of groundwater pollution (3f).

Wastewater at JAAP is primarily cooling water. Acid spills and blowdown also account for some of the wastewater volume. Blowdown is necessary because of the water softeners and contains organophosphate compounds. No treatment is currently provided for these waters. Total wastewater flow at a production rate of 600,000 bl/day 40% oleum was observed to be 1.01 mgd.

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Table I.L.1 presents the results of wastewater analyses on the oleum ditch north of the plant prior to combination with flow from the Acid 3 Area at JAAP. These wastewater characteristics will vary significantly when other production facilities not in operation at the time of the measurements resume production. Flow in this ditch is influenced by rain as well as flow from the acid tank car area.

An idea of the extreme variability in data obtained from wastewater characterization of this ditch can be seen by comparison of data in Tables I.L.1 and I.L.2. Unfortunately, related production data was not available for the information presented in Table I.L.2. Table I.L.3 indicates the nature of the wastewater from acid tank car draining as it enters the oleum ditch at JAAP.

Although eight plants produce or have produced oleum (BAAP, InAAP, VAAP, RAAP, SAAP, AAAP, NAAP, and JAAP), qualitative and quantitative data was available only from JAAP (see above). BAAP, however, did report evidence of biological growth in their oleum waste pond (1a(2)) which may be interpreted as an indicator that these wastes do not constitute a significant source of groundwater pollution.

d. Effects of Process Change on the Wastewaters

No information on planned procedural changes was available.

e. Data Limitations

With the exception of RAAP, poor wastewater characterization data exists, and a lack of information on modernization and pollution abatement plans is evident.

SECTION IV - EXPLOSIVES

25. AMMONIUM NITRATE PRODUCTION

a. Process Description

The reader is referred to Chapter IV of this report for a detailed process description.

Production of ammonium nitrate (NH_4NO_3) is unique to HAAP among Army ammunition plants. It is produced by the direct reaction of anhydrous ammonia and nitric acid, with the reaction taking place in a circulating stream of ammonium nitrate solution. The reaction takes place as follows:

$$NH_3(g) + HNO_3(aq) \longrightarrow NH_4NO_3(aq)$$

This reaction is exothermic, and the heat of reaction must be removed to prevent decomposition of the ammonium nitrate and the possibility of fire or explosion. Ammonium nitrate is produced and supplied to the explosives manufacturing area as a mixture of ammonium nitrate and nitric acid (1d(2)).

b. Water Use and Wastewater Volume

(1) Water Use. Water use figures were unavailable.

(2) Distribution of Wastewater Volumes. Table 22 summarizes the wastewater volumes generated in the production of ammonium nitrate. Process and cooling waters are currently discharged together. Source data for Table 22 can be found in Table I.B.1 (Appendix I).

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Table 23 lists the overall discharges resulting from production of ammonium nitrate.

b. The Effects of Process Change on the Wastewater

Two proposed process changes, segregation of process and cooling waters and ammonia stripping, will have little effect on this waste stream. Ammonia stripping and its associated pH and solids problems would likely worsen the quality of the waste stream rather than improve it. Since the stream appears reasonably "clean," it appears that segregation of cooling waters would also have little effect.

e. Data Limitations

Once again the distressing problem of not being able to determine the source of dissolved solids content prevents a truly detailed and accurate assessment of the character of the waste stream. In addition, where its relative abundance is important, the suspended solids content too should be characterized. Such a characterization does not appear to be necessary for ammonium nitrate production.

TABLE 22
WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF AMMONIUM NITRATE AT HAAP

	Overall
MGD	1.85
Gal per Ton of Final Product	9,250[1]

[1] 400,000 lb/day NH_4NO_3/HNO_3 solution

TABLE 23

OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF AMMONIUM NITRATE AT HAAP

Item	Discharge (lb/day)	Discharge (lb/ton of product*)
NH_3/N	9.40	.047
$NO_2 + NO_3/N$	28.7	.144
TKN/N	17.2	.086
Total Solids	3,060	15.3
Dissolved Solids	3,080	15.4
COD	185	.924
TOC	46.2	.232
BOD	15.4	.077

*Ammonium nitrate produced

26. DINITROTOLUENE (DNT)

At one time DNT was manufactured at JAAP and AAAP. Now, however, DNT is purchased commercially and purified at JAAP by a process known as "sweating." The commercial material is about 75 percent 2,4-DNT and 20 percent 2,6-DNT. The mixture is melted and subjected to a controlled cooling-heating program. In the cooling step, DNT containing mostly the 2,4-isomer crystallizes, while the liquid impurity-rich fraction is drained off (or sweated). This fraction includes most of the 2,6-DNT in a eutectic mixture of about 57 percent 2,6-DNT and 43 percent 2,4-DNT. The remaining solid (about 65 percent of the initial charge) is withdrawn for packaging and shipment. The impurity-rich fraction is added to the intermediate product entering a "bi-house" (the second of three nitration buildings in a batch TNT production line) (2c).

DNT is also formed as an intermediate in the production of TNT. However, DNT discharge as a result of TNT manufacturing operations will be considered in Para. 27 of this Chapter.

DNT is used extensively in smokeless propellant powder. This propellant consists of about 85 percent nitrocellulose, 9 percent DNT, and lesser amounts of dyphenylamine and dibutylphthalate. The main function of DNT is to control the burning rate of the propellant (2c).

An excellent discussion of the sources of DNT wastewaters appears in Reference (2c). Surprisingly, the "sweating" process generates only minor amounts of DNT-containing wastewater. Much more significant DNT-containing wastewaters result from the preparation and production of smokeless powder and TNT.

DNT wastes appear to be somewhat resistant to biodegradation.

27. TNT PRODUCTION

a. Process Description

TNT (or more specifically, α-TNT) is the common designation for 2,4,6-trinitroluene, the military high-explosive manufactured in greatest quantity. Along with α-TNT, five TNT isomers are found in the crude product of the reaction of toluene with nitric acid in the presence of sulfuric acid. The nitration occurs in steps, and the nitro groups initially introduced deactivate the intermediates towards further nitration. Hence, toluene is first treated with a mixture of 60% nitric acid and 70% sulfuric acid, while a mixture of 109% sulfuric acid (sulfuric acid containing 40% sulfur trioxide) and 98.5% nitric acid is needed for the final nitration. The process is carried out in batches or continuously. Following nitration, crude TNT is "scrubbed" by washing with water to remove acid. In the continuous process, most of these washings ("yellow water") are returned to an early state nitrator; any non-recycled yellow water is incinerated. Spent acid is sent to a spent acid recovery (SAR) unit. Crude TNT contains about 5% of the undesirable isomers. These isomers are removed by washing the crude product with 16% aqueous sodium sulfite ("sellite"). The TNT is further washed, solidified, flaked and bagged for shipment (2b).

TNT wastes have a unique terminology. "Nitrobodies" include α-TNT, other isomers, sellite process products and by-products from the production process. The high-solids spent "sellite" washings (see above) are called "red water." Such water is intensely red-colored and is either sold to paper mills for sulfur content or is concentrated by evaporation and incinerated. It is not amenable to purification and discharge into streams. "Pink water" comes from both manufacturing plants and LAP's. That from manufacturing plants arises from Mahon fog filter effluents (Volunteer AAP batch process only); nitrator fume scrubber discharges; "red water" distillates; finishing building hood scrubber and washdown effluents; and possibly spent acid recovery wastes. The first two types of "pink water" may contain TNT isomers, and the first three may contain dinitrotoluenes. "Pink water" from LAP's, resulting primarily from shell washout operations, contains essentially pure TNT, usually contaminated with RDX or other additives. The "pink" color -- pale straw to brick red -- arises under neutral or basic conditions, especially when the wastes are exposed to sunlight. The breakdown products of TNT responsible for this color have not been identified (10a). Research is being conducted to identify the degradation products of TNT in "pink water," notably at the Naval Ordnance Laboratory White Oak, Maryland, at Tufts University, Boston, Massachusetts (15b), (15c) and at US Army Natick Laboratories (16a, 16b), Natick, Massachusetts (2b).

At present, TNT is produced at Volunteer, Joliet, and Radford AAP's. The Radford plant is currently the only plant exclusively using the continuous process to produce TNT; the other two plants are installing continuous lines. A fourth AAP, Newport, has continuous TNT lines and the most advanced designs in peripheral acid production and pollution abatement. This plant was scheduled for startup in early FY74. The activity of these plants is summarized in Table 24 (2b). RAAP and JAAP are discussed below. These two plants were the only AAP's possessing available wastewater characterization data at the time of the present study.

TNT is used at Holston AAP (HAAP) for blending into their HMX and RDX for explosives such as "Composition B," "Cyclotol 70/30," and "Octol." Table 25 presents 1970 HAAP production data which approximates current levels (2b).

The reader is referred to Chapter IV of this report for further process details.

b. Water Use and Wastewater Volumes

(1) Water Use. Current water usage in the TNT area at RAAP is estimated to be 5.15 mgd (6a). This is in close agreement with the USAMEERU report which records a "pink water" discharge stream volume of 163,000 gpd diluted with about 4.5 mgd of cooling water (2b) Water usage figures from JAAP were not available.

(2) Distribution of Wastewater Volumes. Major wastestream volumes from TNT production at RAAP are detailed in Tables I.R.1 through I.R.7, and major wastewater volumes at JAAP are detailed in Tables I.R.8 through I.R.10 (Appendix I). Assuming three active (continuous) production lines at RAAP and six active (batch) production lines at JAAP, overall wastewater discharges from the manufacture of TNT at these two plants is depicted in Table 26. These waste streams do not include the wastewater generated in the Acid Neutralization and Red Water Treatment Facilities.

Figure 1 details the process flow and wastewaters generated in a typical batch production line at JAAP.

Treatment of TNT wastewaters will be discussed in Chapter IV .

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Wastewater characterizations of the major wastestreams generated at RAAP and JAAP appear in Tables I.R.1 through I.R.7 and I.R.8 through I.R.10, respectively. These results are summarized in Table 27 assuming three active production lines at RAAP and six active lines at JAAP.

In general, the major pollutants generated in TNT production are nitrobodies, nitrates, sulfates, and pH. In addition, significant quantities of Na_2SO_3, $NaNO_2$, $NaHSO_3$, and sodium trinitromethane sulfonate are generated.

d. Effects of Process Change

(1) RAAP. At RAAP a cooling tower will be constructed to replace the once-through cooling water system (MCA 105D(a)). Blowdown from the tower will be controlled so that the dissolved solids content is within acceptable discharge limits (6a).

Acidic and non-acidic contaminated wastewaters will be segregated. An area will be provided for storage of these waters and equalization of any shock loads. The segregated wastewater will be reused in the TNT manufacturing operations (6a).

Rainwater which becomes contaminated will be treated and released (6a).

Also, a study (PE-290) will provide for improvement of water usage at RAAP. TNT process wastewaters are expected to decrease 100 percent from their current level of 150,000 gpd. Current cooling water usage of 5×10^6 gpd is expected to be reduced to approximately 500,000 gpd -- a 90 percent reduction (6a).

(2) JAAP. No information regarding proposed process changes was available at the time of this study.

e. Data Limitations

Significant analytical data was available from only two of the four AAP's producing TNT. In addition, major process modifications at RAAP and new and modern facilities at NAAP will lead to the generation of wastewaters of a highly different nature in terms of pollutant concentrations. It is suggested here that a wastewater characterization study closely correlated with production is necessary as soon as production at NAAP and JAAP has normalized using the new equipment.

Future plans for process changes at JAAP and VAAP should be specified.

TABLE 24
PRODUCTION OF TRINITROLUENE IN LATE FY73 (2b)

Plant	Lines Available	Lines Active	Type Production	Recent Production lb/mo	Cited Capacity lb/mo
Radford	3	3	Continuous	9-10,000,000	9,000,000
Joliet	12	6	Batch	18,000,000	36,000,000
Volunteer	10	4	Batch*	6,000,000	30,000,000
Newport	5	1**	Continuous	3,000,000	15,000,000

* Continuous lines under construction.
** Planned for FY74.

TABLE 25
1970 TRINITROTOLUENE USAGE AT HOLSTON ARMY AMMUNITION PLANT (12a, 1d(2))

Explosive	Composition	Amount Produced, 10^3 Pounds	Explosive Requirements, 10^3 Pounds		
			RDX	HMX	TNT
Composition B	60% RDX, 39% TNT, 1% wax	168,700	101,000		66,000
Composition B-4	60% RDX, 39.5% TNT, 0.5% Calcium Silicate	16,500	9,900		6,500
Cyclotol	70% RDX, 30% TNT	10,010	7,010		3,000
Octol	75% HMX, 25% TNT	2,860		2,140	720
		198,070*	107,910	2,140	75,220

* Total 1970 Production cited at 211,927,000 pounds.

TABLE 26

WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF TNT (1n(3), 1g(3))

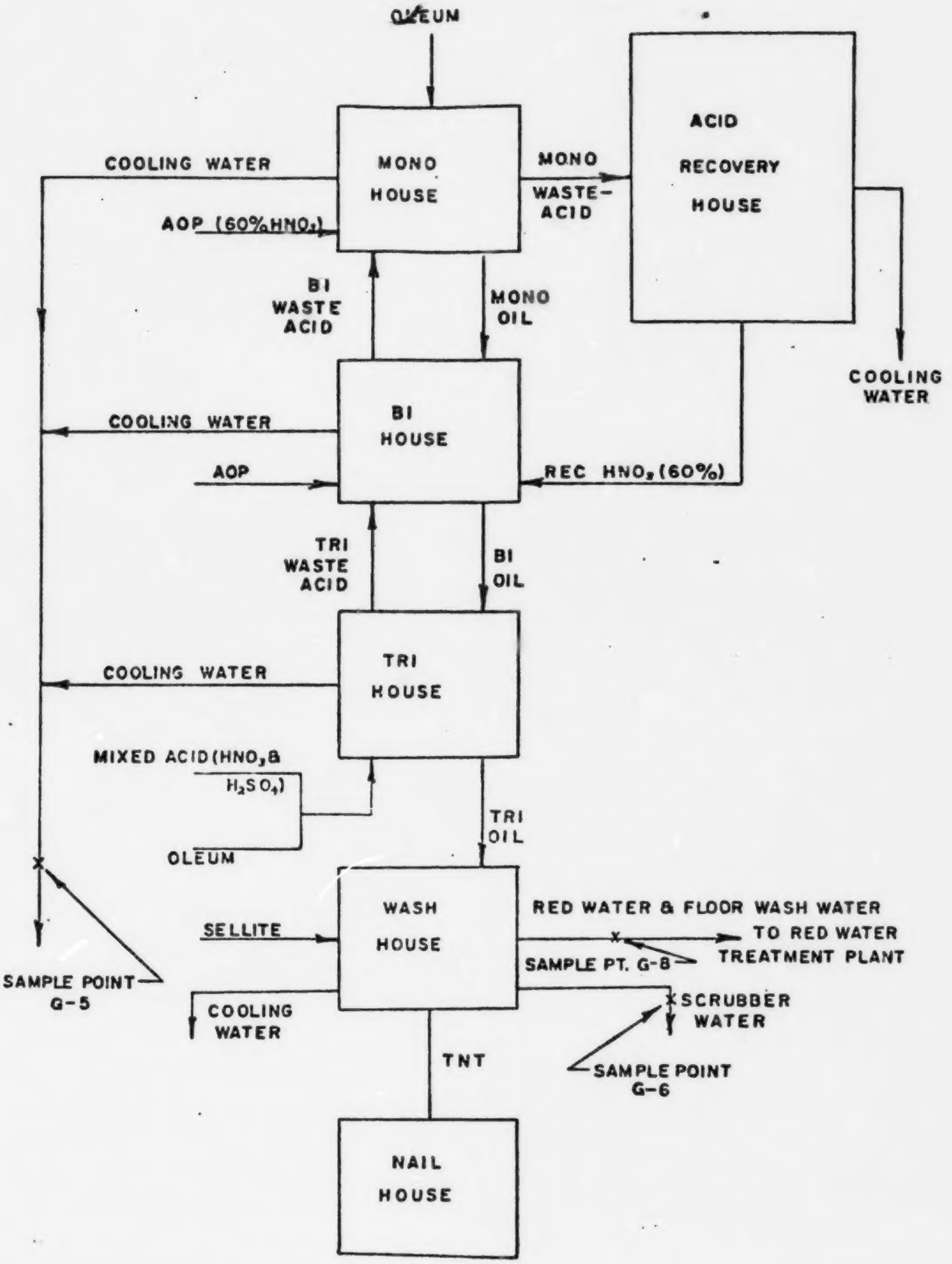
Unit	RAAP	JAAP
mgd	2.63	9.60
Gal per Ton of Final Product	18,100	31,800

TABLE 27
OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF TNT (ln(3), lg(3))

AAP	RAAP*		JAAP**	
Chemical Parameter	Discharge (lb/day)	Discharge (lb/ton of product)	Discharge (lb/day)	Discharge (lb/ton of product)
Acidity/$CaCO_3$	2,700	18.6	1,290	4.27
Alkalinity/$CaCO_3$	2,530	17.4	12,200	40.4
Total Solids	10,500	72.4	83,274	275
Suspended Solids	1,510	10.4	1,240	4.10
Dissolved Solids	8,980	61.9	80,700	267
Volatile Solids			35,600	117
COD	620	4.27		
TKN	30.9	.213	511	1.69
NO_2 + NO_3/N	255	1.76		
NO_3/N			1,270	4.20
SO_4	5,230	36.1	39,600	131
TNT	167	1.15	60	.199
TOC			11,400	37.7
Sulfides			476	1.58

*145 ton/day TNT produced; **302 ton/day TNT produced

FIGURE 1
TNT BATCH PRODUCTION PROCESS. JAAP (1g(3))


OLEUM
COOLING WATER
MONO HOUSE
MONO WASTE-ACID
ACID RECOVERY HOUSE
AOP (60% HNO3)
BI WASTE ACID
MONO OIL
COOLING WATER
COOLING WATER
BI HOUSE
AOP
REC HNO3 (60%)
TRI WASTE ACID
BI OIL
COOLING WATER
TRI HOUSE
MIXED ACID (HNO3 & H2SO4)
OLEUM
TRI OIL
WASH HOUSE
SELLITE
RED WATER & FLOOR WASH WATER
TO RED WATER TREATMENT PLANT
SAMPLE PT. G-8
SAMPLE POINT G-5
COOLING WATER
SCRUBBER WATER
TNT
SAMPLE POINT G-6
NAIL HOUSE

28. TETRYL PRODUCTION

Tetryl (2,4,6-trinitrophenyl methyl nitramine) has been used as a booster explosive, or the explosive ignited by a detonation charge, which in turn detonates the bursting charge. Its sensitivity and explosive properties are similar to those of RDX. Because of this similarity, economic considerations, and the explosive and toxic hazards involved with handling dry tetryl, the Army has phased out tetryl production (15d). The RDX-based explosives Composition A-3 and Composition A-5 are being used as boosters in lieu of tetryl in many munitions (15e). Sufficient supplies of tetryl are on hand to handle the limited anticipated needs of the Army and other services (2c).

At IAAP, booster charges are molded from bulk explosives. Currently, about 11,000 lb/day of tetryl are so processed (3.o). Only small amounts of tetryl-containing wastewater, estimated at 1,500 gallons/week, are generated (3.o). This wastewater is transported to a sedimentation pond, for which no estimate of tetryl content is available (2c)

a. Process Description and Wastes Generated

Tetryl production was confined to JAAP, and ceased as of 31 July 1973 (8b). The process was carried out in a batch mode. The starting material, N,N-dimethylaniline was dissolved in 96-99% sulfuric acid. This mixture was pumped to a nitrator house wherein it was reacted with about 9 parts of 67% nitric acid for 70 minutes. The crude product was isolated from the spent acid, washed four times and sent to a refinery house. These washes removed more soluble impurities such as 2,3,4,6-tetranitrophenylnitramine from the crude tetryl. At the refinery house, the tetryl was dissolved in aqueous acetone solution. The acetone was distilled off, leaving a better sized product in the remaining water. This process water was discarded, the tetryl given a final wash, screened, and sent to be dried and packaged. The major source of tetryl in wastewater was from the four washes in the nitrator house; a second important source was from the process water discarded after the refining step. Additional tetryl was discharged during periodic washdowns of floors in the various processing buildings (2c). A process flow diagram including points of wastewater discharge is presented in Figure 2.

Since tetryl is no longer produced at JAAP, any tetryl discharges to surface or subsurface waters would now emanate from ground deposits. It would seem that cooling water in the amounts cited, at 20°C, would have sufficed to dissolve all discharged tetryl. Yet, in 1969, during production, Griffin reported tetryl particles visible in the drainage ditches (3p).

A visit was made to JAAP on 14 August 1973 to collect water and soil samples (8b). At the time of the visit, nitrator houses 10 and 11, which had just ceased operation, were being cleaned out. The nitrator ditch was running full; this precluded sampling from that ditch. The refinery ditch was receiving some water from refinery house 10, but flow was slow and sluggish. A sample transect was found in the ditch downstream of refinery houses 10 and 11, where the width of flow narrowed. The samples collected from there are presented in Table 28 (2c).

Except for the surface water sample, tetryl was detected in all samples. The presence of tetryl in sample 3 was probably due to seepage of surface water through tetryl-rich soil. The depth of tetryl-rich soil is not known. It does not appear to be very wide, as evidenced by the much lower concentration in sample 6 as compared to sample 4. Surface soils had much lower tetryl contents than sub-surface soils at the same location. Cleanout waters may have leached surface soils of tetryl faster than tetryl could diffuse to the surface from sub-surface water. Evidence for this is inferred from the presence of an unidentified compound, perhaps removed in the refining process, in samples 1, 3, 4, and 6, but to a much lesser extent in surface soil samples. This impurity was also noted in the production grade tetryl used for analytical calibration (2c).

The transect selected was considered a likely place to isolate tetryl-rich soil, and concentrations may decrease further downstream. There are probably tetryl deposits in the nitrator ditch since most tetryl discharges went there (2c).

A rough estimate of potential tetryl loadings at JAAP may be determined from reasonable assumptions of drainage area, rainfall, run-off, and the amount of tetryl dissolving into ditchwater from the ground. The drainage area of the tetryl ditches is estimated to be about 800 feet by 1200 feet or 960,000 feet (15f). Rainfall at JAAP is assumed to be the same as that at Chicago, or 33.2 inch/year (16c). If winter is represented as December-February, etc., the seasonal rainfalls are: winter, 5.4 inch; spring, 9.4 inch; summer, 10.7 inch; and fall, 7.7 inch. The average run-off temperature is assumed as 0°C for winter, 10°C for spring, 25°C for summer, and 13°C for fall. The last three temperatures are the respective average April, July, and October temperatures for Chicago (16c). The tetryl area, other than that occupied by buildings and roads, is grassy and flat. The underlying strata are considered impermeable; hence somewhat larger percentages of run-off than expected for grassy, flat areas are assumed. A winter run-off of 50% is assumed, a 40% run-off in the spring and fall, and a 30% run-off in the summer. It is further assumed that all run-off becomes saturated with tetryl. Based on these assumptions, the seasonal loadings of tetryl would be: winter, 710 lb; spring, 1210 lb; summer, 1370 lb; and fall, 1080 lb. The yearly total is 4470 lb or a nominal 12 lb/day tetryl loading. In terms of an Illinois River low flow of 1500 mgd, a river concentration of 0.001 mg/l is obtained. This is probably a high-sided estimate, since normal rainfall usually causes normal flow conditions (2c).

The amount of tetryl in soil at JAAP is estimated at 31,000 lb. This estimate is based on the assumptions that all tetryl is in the nitrator and refinery ditches; each ditch is 1000 ft long; the tetryl is contained in a 2 ft deep by 1 ft wide section in each ditch; there is a mean soil content of 5% tetryl in these sections; and the soil has a 2.5 g/cc bulk density. At a constant depletion rate of about 4,500 lb/year, the soil would be leached of all tetryl in seven years. Hence, the chronic aspects of potential tetryl toxicity based on an 0.001 mg/l concentration may be quite limited (2c).

b. Water Use

Water usage data was unavailable.

c. Distribution of Wastewater Volumes

The following are estimates of wastewaters generated from the production of tetryl on one of JAAP's twelve lines, assuming 3-8-5 operations* and a 150,000 lb/mo per line production rate: (a) from a nitration house, about 0.7 mgd cooling water and about 20 batch dumps per day of wash water. Each dump contained about 410 gallons with a tetryl concentration of about 460 mg/l; and (b) from a refinery house, about 0.2 mgd cooling water and about 8 batch dumps per day of process water (2c). Each dump contained about 150 gallons (15g) with a tetryl concentration of about 400 mg/l. The daily discharge of tetryl from each line, based on the above data, was 36 lb/day. These wastewaters were routed through two parallel drainage ditches, one serving the nitrator houses and one serving the refinery houses (2c).

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*This is a common notation for three eight-hour shifts per day, five days per week operations. (15g)

d. Qualitative and Quantitative Aspects of the Liquid Wastes

The results of three separate studies are presented in Tables I.Q.1 through I.Q.3 (3f), I.Q.4 and I.Q.5 (1g(3))and I.Q.6 (8a). These results and the determinations made in the USAMBRDL study (2c) are summarized in Table 29. A high variance in the data obtained is immediately apparent upon examination of Table 29. Unfortunately, only two of the investigations (1g(3) and (2c)) included related production data.

e. Effects of Process Change on the Wastewaters

Production of tetryl has been discontinued at JAAP.

f. Data Limitations

A definitive study characterizing the wastes from this area apparently cannot be done since production has been terminated.

TABLE 28

ASSAY OF WATER AND SOIL SAMPLES FROM TETRYL REFINERY DITCH JOLIET ARMY AMMUNITION PLANT, 14 AUGUST 1973 (8b)

SAMPLE	DESCRIPTION	TETRYL CONTENT mg/l Liquid or mg/10 g Soil
1	Standing water in ditch	0
2	Surface soil approximately 6 inches from edge of flow	4.72
3	Seepage water from 4-inch deep hole dug at site of sample 2	44
4	Sub-surface soil from hole dug at site of sample 3	844
5	Surface soil approximately 2 feet from edge of flow	5.62
6	Sub-surface soil, 4 inches deep from site of sample 5	14.5

FIGURE 2
TETRYL PRODUCTION. JAAP (1g(3))

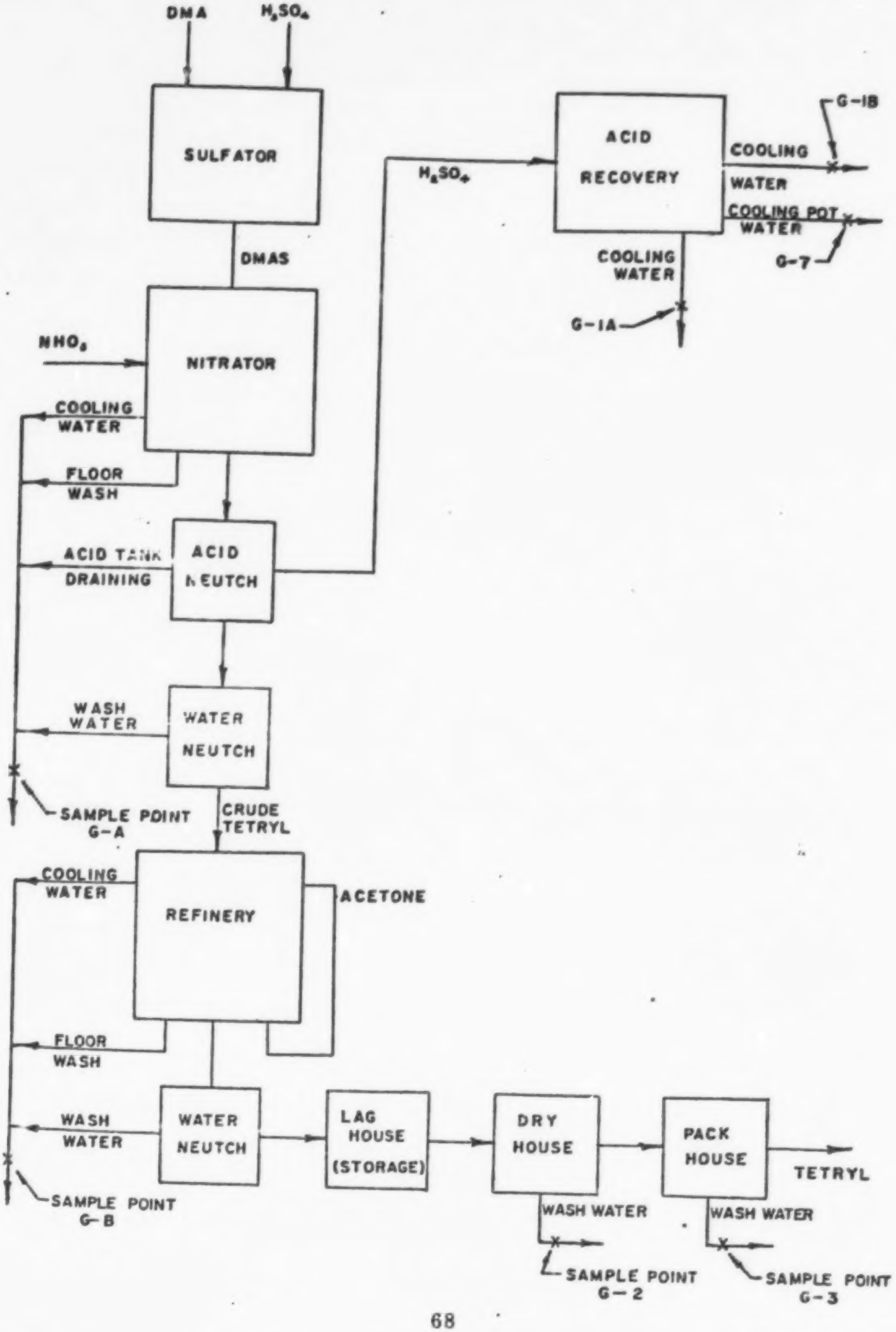

DMA
H_2SO_4
SULFATOR
DMAS
HNO_3
NITRATOR
COOLING WATER
FLOOR WASH
ACID TANK DRAINING
ACID NEUTCH
H_2SO_4
ACID RECOVERY
COOLING WATER
G-1B
COOLING POT WATER
G-7
COOLING WATER
G-1A
WASH WATER
WATER NEUTCH
SAMPLE POINT G-A
CRUDE TETRYL
COOLING WATER
REFINERY
ACETONE
FLOOR WASH
WASH WATER
WATER NEUTCH
LAG HOUSE (STORAGE)
DRY HOUSE
PACK HOUSE
TETRYL
SAMPLE POINT G-B
WASH WATER
SAMPLE POINT G-2
WASH WATER
SAMPLE POINT G-3

TABLE 29
RESULTS OF ANALYTICAL STUDIES: TETRYL PRODUCTION. JAAP

Parameter \ Study Reference:	(q.1)	(q.2)	(q.3)	(q.6)
Flow (mgd)	1.21	1.91	.245	.909
Gal per Ton of Product		406000		266568
Acidity as $CaCO_3$ (lb/day)	16793	3,760	40600	
SO_4 (lb/day)	16200	9850	37800	
NO_3/N	3270		5510	
Total Solids (lb/day)		9870		
Dissolved Solids (lb/day)		8760	44500	
Volatile Solids (lb/day)		6573		
TOC (lb/day)		96.4		
COD (lb/day)			755	
Tetryl (lb/day)			847	36

29. BLENDS INCLUDING RDX, HMX, AND EXPLOSIVE FORMULATIONS DERIVED FROM THEM WITH EMPHASIS ON COMPOSITION-B

Figure 3 depicts the molecular structure for RDX, HMX, and related compounds. Both RDX and HMX are more powerful explosives than TNT, but they are also considerably more susceptible to shock detonation than is TNT. The explosive mixtures offer a compromise of properties.

RDX and HMX are found in numerous explosives mixtures. HMX is used as a component of solid-fuel missile rocket propellant. Mixtures of RDX and wax, "Composition-A" explosives, are suitable for press loading into small artillery shells. Compositions A-3 and A-5 are being used for booster charges in many Army munitions in lieu of tetryl. Mixtures of RDX and HMX with special plasticizers and solvents give rise to numerous plastic explosives and demolition charges designated as "Composition-C," "PBX," or "PBXN" explosives. RDX and HMX find widest use as burster charges for artillery shells. For this use they are mixed with TNT to form mixtures called "Composition-B," "cyclolols," or "octols." The most extensively produced of these is "Composition-B" which contains 60.5 percent RDX, 38.7 percent TNT, and 0.8 percent wax. Composition-B is readily melted for pouring into shells, and, after solidification, can be drilled for insertion of nonbursting charge components. Table 30 indicates 1972 production for the most extensively produced RDX- and HMX-derived explosives. It has been estimated that Table 30 production figures represent about 95 percent of the total RDX output and 85 percent of the total HMX output (2c).

a. Process Description

RDX, HMX, and the explosive blends derived from them are produced at HAAP. The reader is referred to Chapter IV of this report for a more detailed process description.

RDX is formed by reacting hexamine (hexamethylenetetramine) with ammonium nitrate/nitric acid mixture in the presence of acetic acid and acetic anhydride. The initial product contains roughly 79 percent RDX, 6 percent HMX, and various intermediate products. The major single intermediate appears to be "BSX" ($CH_3COOCH_2-N(NO_2)-CH_2)_2-N-NO_2$). The primary reaction mixture goes through an aging and simmering process to convert such intermediates to RDX or decompose them. HMX is not considered detrimental to RDX performance and is neither destroyed or recovered from the product. Military grade HMX and RDX each contain some amounts of the other explosive (2c).

When this reaction mixture is cooled, most of the crude RDX precipitates. Nearly all the supernatant liquid is drawn off by vacuum and transferred to a recovery building. Here HNO_3 is neutralized with sodium hydroxide slurry, and about 80 percent of the resulting solution is then evaporated. Acetic acid is recovered from the vapors and sent to Area A for reuse (see Para. 20, Chapter V). The remaining solution is heated to about 100°C and slowly cooled to 30°C. RDX is crystallized from the supercooled solution by seeding and is sent back to the main process for purification. More sodium hydroxide slurry is added to the residual solution to convert any remaining ammonium nitrate and explosive to sodium nitrate and ammonia, and any acetic acid to sodium acetate. The ammonia vaporizes and is condensed for purification and sale as fertilizer. Impurities such as methylamine and dimethylamine preclude its reuse. The sodium nitrate formed has been stored in ponds for processing into fertilizer since an old processing facility burned down in 1969. A new processing facility became operational in 1974 (2c).

After vacuum filtering, the crude RDX is water washed, and the wash water is withdrawn by vacuum and recycled to the simmering process cited above. The RDX is then slurried in additional water and transferred to a recrystallization building. There cyclohexanone is added to the slurry, the slurry heated, and the cyclohexanone distilled. RDX recrystallizes in particles of acceptable size. Then RDX in water slurry is poured into special vacuum carts (nutsches) and most of the water is withdrawn. The resulting explosive contains about 10 percent water (2c).

TNT from other Army ammunition plants is melted with steam in 550-pound batches and transferred to incorporation kettles. Wet RDX is next added to the molten TNT. The water content of the RDX rises to the surface of the melts and is decanted during RDX addition.

The formation of HMX requires the same reactants as are used for RDX, but in different proportions. A hypothetical 100-pound reactant charge consists of: 11 pounds of the ammonium nitrate/98 percent nitric acid mixture cited previously; 17 pounds of the hexamethylenetetramine/acetic acid mixtured cited previously; 54 pounds of acetic anhydride; and 18 pounds of acetic acid. The reaction is carried out in batch fashion. About 27 percent of the crude product mixture is RDX, whereas specification grades of HMX may contain only 2 or 7 percent RDX. Most of the RDX is extracted in the acid drawoff by vacuum and the washing step, and eventually is added to RDX production. The HMX recrystallization process is usually done with acetone (2c).

b. Water Use and Wastewater Volume

(1) Water Use. Water usage data for the explosives production line was not available.

(2) Distribution of Wastewater Volumes. Examination of Table 31 reveals that the overall wastewater discharged from the explosives production lines (HAAP Area B) during a recent USAEHA study (1d(2)) averaged 30.3 mgd. To the extent possible the flows contributing to this overall figure have been itemized in this table. Also, overall wastewater volumes have been related to the Composition-B production rate at the time of the study; however, itemized flows have generally been related to the immediate product of that step. This is to ensure that the researcher can extract data relating to only HMX, RDX, or blended explosives (viz. Composition-B).

Unlike HAAP Area A, some segregation of cooling and process wastewaters has been effected in Area B. It has been possible to distinguish between these for the nitration and recrystallization steps described in Tables 31 and 32.

Note that the cooling water requirement for recrystallization operations carried out in buildings G-2, 3, 4, and 8 accounts for 80.2 percent of the calculated wastewater generated in explosives production.

c. Qualitative and Quantitative Aspects of the Liquid Wastes

Effluents from the explosives production lines dump directly into the HOlston River after settling of these wastes in catch basins located at each building in the production line. The process effluents are characterized by the presence of: soluble explosive compounds such as RDX, HMX, and TNT; solvents such as acetone and cyclohexanone; nitrogenous organic compounds; and a high dissolved solids content. Inspection of Table 32 and Tables I.C.1 through I.C.11 (Appendix I) again reveal that the major constituent(s) of the dissolved solids have not been identified.

In the explosives production area proper, process wastewaters are emptied to process sewers, and cooling waters are discharged to open ditches. HAAP had planned to route the process wastes to an aerated lagoon where biological degradation of wastes could occur. Expectation for successful treatment in this manner was derived from high BOD measurements on many of the waste streams. In addition, the relatively low (by industrial waste standards) BOD/COD ratio (2.28; see Table 32) for the overall discharge supports this view. However, EPA has established a precedent by ruling out such a plan for HAAP Area A wastes. It was claimed (by EPA) that such treatment would not provide sufficient reduction and does not include the best practical control technology currently available (2c).

In 1972, Green (16d) used a 70-liter pilot activated sludge unit with a five-day hydraulic retention time to treat plant wastes containing cyclohexanone, acetone, RDX, HMX, and TNT. The major genera of the active mass were *Pseudomonas* and *Alcaligines*. Partial degradation of these materials was indicated. Burrows (2d) presents a detailed overview of the chemistry, toxicology, and biodegradability of RDX/HMX wastes.

The major explosives sources from the processes described in Para. 29 are the steps involved in dewatering of RDX in nutsches and in decanting water from the hot RDX/TNT mixtures. These steps take place in Buildings H-2, 3, 4, 8 and in Buildings J-1, 2, 9; I-1, 2, 9: L-1, 2, 9; and M-1, 2, 3, 9; respectively, and are referred to in Tables I.C.6 and I.C.7, respectively. The major HMX-containing discharges arising from production of HMX also occur during the dewatering and incorporation steps. However, sufficient HMX is present in the RDX, as produced, so that more HMX enters wastewater from RDX production than from HMX production (2c).

Estimates of RDX and HMX loadings are based on data presented in Table 33. The RDX data are from a study performed by the EPA in April 1973 (15h) as a follow-up to their December 1972 investigations (15i). The April 1973 study featured an intensive analysis of organic species, in which the gas chromatograph and mass spectrometer were used. Flow measurements were also performed during the April study; hence mass loadings based on these data can be directly calculated. The concentrations used in these calculations are taken from 24-hour time composite samples. During the 24-hour period of April 2-3, 1973, about 1200 pounds of RDX were discharged; during the 24-hour period of April 3-4, 1973, about 910 pounds of RDX were discharged. HAAP performs analyses of grab samples collected once weekly from these outfalls. A summary of the RDX assays for the first six months of 1973 (15j) appears in Table 33. Unfortunately, concurrent flow measurements from which load comparisons to the EPA results might be made were not performed by HAAP. It does appear that, even in periods of steady production, RDX concentrations in wastewaters are subject to wide variation and that the EPA assays probably represent a period of rather heavy explosives discharge (2c).

The EPA study did not include HMX analyses. Such assays are performed by HAAP on weekly grab saples, and the results of these from the first half of 1973 are summarized in Table 33. The "HMX content for purposes of overall estimate" concentrations in Table 33 are mean concentrations plus one standard deviation. An HMX loading of 207 lb/day is based on these concentrations and averaged EPA flow data. This method is not rigorous, since RDX and HMX concentrations from HAAP assays are not highly correlated, and flows are subject to variation. The loading estimate should tend to be on the liberal side. For estimation purposes, 1000 lb/day of RDX and 200 lb/day of HMX are assumed to be discharged into 520 mgd of Holston River flow (2c).

The explosive wastes from HAAP also include by-products of RDX and HMX processing that carry through the purification process. Two of these, known as "TAX" and "SEX," and whose structures appear in Figure 30 , are the most abundant by-products. HAAP does not assay quantitatively for these compounds (16e, 2c)).

Table 32 indicates an average daily discharge of 124 lb RDX and 45.2 lb HMX. In comparison to 1000 lb/day RDX and 200 lb/day HMX cited above, Table 33 values represent 12.4 and 22.6 percent, respectively, of these figures. Data in Table 32 are based on the 1971 USAEHA study (1d(2)), and, although they are not unreliable, they are generally inconclusive since the same parameters were not measured at each location and since flow data omissions are frequent. The data is erratic; methodology and equipment used to obtain the data are not discussed in the source document (1d(2)); and failure to obtain a mass balance is evident -- i.e., sources of total and dissolved solids, COD, and BOD cannot be determined from the sum of other constituents presented in the table. It may be hypothesized that the high BOD and COD values not accounted for by total organic carbon measurements are the result of a nitrogenous oxygen demand. However, the sum discharge of all organic nitrogenous compounds from the explosives production lines is only 2.28 lb/day as nitrogen if one uses the cited TKN/N discharge, 9.56 lb/day, and corrects this value for the NH_3/N, 7.28 lb/day -- all in all, a highly unlikely figure when one considers the sum of discharges of TNT, hexamine, RDX, and HMX also cited in Table 32. It is therefore evident that the usefulness of this table lies in its ability to indicate the qualitative nature of discharges resulting from production of RDX, HMX, and blended explosives. These discharges have been itemized in Tables I .C.1 through I.C.11, but, in general, they suffer from the same deficiencies (cited above) as does Table 32 itself. This is not too surprising considering that they are source documents for calculations presented in Table 32.

The ammonia recovery process is discussed in connection with explosives production since the waste stream on which it operates is generated in the explosives production area. However, it would be equally logical to consider this process as a separate entity or in connection with acetic acid recovery from which it directly receives the liquid wastes.

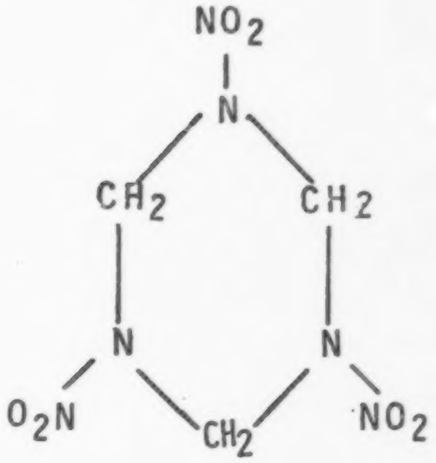
The 1971 USAEHA study (1d(2)) indicates that some reduction in pollutant discharge is achieved by catch basins located outside the production buildings in the explosives manufacturing area. Tables I.C.2 through I.C.7, I.C.10, and I.C.11 illustrate this reduction. To what extent cleaning of these basins resuspends and solubilizes materials deposited in them is unknown. HAAP officials have, however, expressed a desire to institute a vacuum cleaning system rather than retain the current hand-dipping method of cleaning.

d. The Effects of Process Change on the Wastewaters

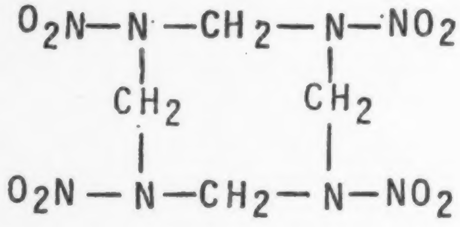
A great deal of uncertainty has existed as to the best method for treatment of wastewaters generated in explosives production (HAAP Area B). Aeration in treatment ponds has been objected to on the grounds that, although COD and BOD are effectively removed, removal of RDX/HMX, cyclohexanone, and other slightly soluble organics is questionable. Little in the way of process change has been suggested to reduce the discharge load requiring treatment. Tank dikes to contain possible spills are being constructed. However, cooling and process waters have already been segregated, and it appears that recycle is not going to be considered in the near future.

e. Data Limitations

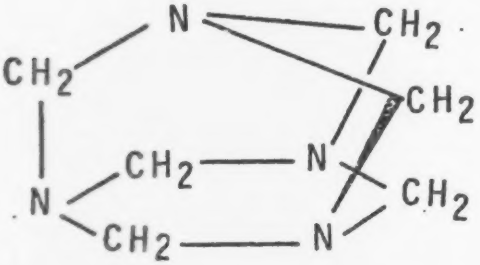
The data base necessary for an extensive characterization of the liquid wastes from explosives production does not exist. This becomes obvious when one attempts a mass (ion) balance using calculations presented in Table 32. Moreover, there are indications that discharge loads are highly variable both qualitatively and quantitatively. It appears that an extensive monitoring program over a fairly lengthy time period would be necessary to characterize the various waste streams arising from explosives production. It is doubtful that the returns from such a study would justify the expenditure since plant treatment facilities are generally designed to treat the combined liquid wastes from many processes.



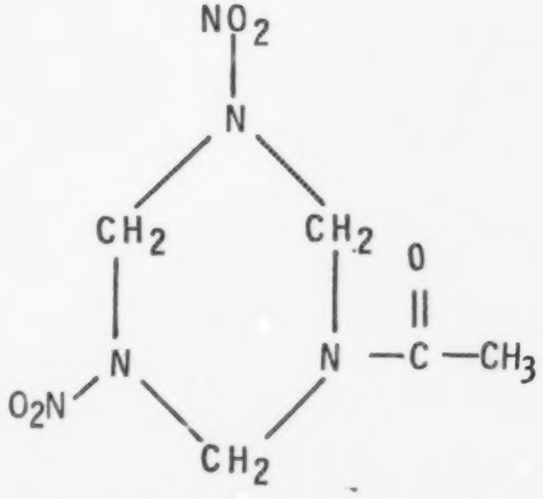
RDX



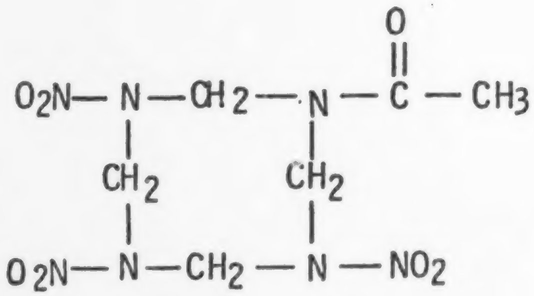
HMX



Hexamethylenetetramine (Hexamine)



"TAX"



"SEX"

FIGURE 3
MOLECULAR STRUCTURE OF RDX, HMX, AND RELATED COMPOUNDS (2c)

TABLE 30

1972 PRODUCTION FIGURES FOR PRINCIPAL HMX/RDX BASED EXPLOSIVES (2c)

Explosive Product	Components	Production, 10^6 lb	Amount of Cited Explosive in Product, 10^6 lb		
			RDX	HMX	TNT
Composition A-3	91% RDX, 9% Wax	2.41	2.19	---	---
Composition A-5	98.5% RDX, 1.5% Wax	1.68	1.66	---	---
Composition B	60.5% RDX, 38.7% TNT, 0.8% Wax	152.10	92.02	---	58.86
Composition B-4	60.5% RDX, 39.0% TNT	2.64	1.60	---	1.03
Composition C-4	91% RDX, 9% Plasticizers and Desensitizers	2.46	2.24	---	---
Cyclotol	70% RDX, 30% TNT	3.06	2.14	---	0.92
Octol	75% HMX, 25% TNT	3.18	---	2.38	0.80
Totals		167.53	101.82	2.38	61.61

TABLE 31
WASTEWATERS GENERATED IN THE PRODUCTION OF BLENDED EXPLOSIVES AT HAAP

Item	MGD	Gal. per Ton of Final Product
Ammonia Recovery		
Building A-1	1.51	252,000[1]
Acid Mixture Distribution		
Building C-5 (Composition-B Production)	0.0176	64[2]
Building C-3 (PBX Production)	0.004	5,000[3,4]
Nitration Buildings		
Building D-6 (HMX Production)		
Process	0.0188[3]	7,134[3,5]
Cooling	1.73[3]	656,000[3,5]
Buildings D-1,2,8 (RDX Production)		
Process	0.150[6]	904[7]
Cooling	1.42[6]	8,550[7]
Slurry Processing		
Buildings E-2,3,4,8 (RDX Production)	0.191[6]	5,000[7]
Building E-6 (HMX Production)	0.00924[3]	3,620[3,5]
Recrystallization		
Buildings G-2,3,4,8 (RDX Production)		
Process	0.110[6]	664[7]
Cooling	24.3[6]	147,000[7]
Building G-6 (Specialty Products)		
Process	0.136[3]	N.A.[8]
Cooling	N.A.[8]	N.A.[8]
Grinding and Dewatering		
Buildings H-2,3,4,8 (Dewatering only; RDX Production)	0.154	930[7]
Building H-6	0.092	N.A.[8]

TABLE 31
(continued)

Item	MGD	Gal. per Ton of Final Product
Incorporation		
Buildings J-1,2,9; I-1,2,9; L-1,2,9; M-1,2,3,9	1.55[6]	5,640[2]
Buildings I-3;J-3;L-3	0.153	680[2]
Buildings L-5;M-5	0.106	471[2]
Receipt of TNT		
Buildings K-1,3,7	0.0518[6]	230[6]
Packaging of Explosives		
Building K-5	0.0173	76.9[2]
Packaging and Loading of Explosives		
Buildings N-1,2,3,4,5,6,8	0.524[6]	2,330[2]
Overall	30.3[2]	135,000[2]

[1] 12,000 lb/day (6 ton/day) anhydrous NH_3 produced.

[2] 550,000 lb/day (275 ton/day) Composition-B produced.

[3] Not included in estimate of overall wastewater volume generated in the production of Composition-B.

[4] 1,600 lb/day (0.8 ton/day) PBX produced.

[5] 5,270 lb/day (2.635 ton/day) HMX produced.

[6] Estimated.

[7] 331,200 lb/day (166 ton/day) RDX produced.

[8] NA = not available.

TABLE 32
OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF BLENDED EXPLOSIVES AT HAAP

Item	lb/day	lb/ton of product
Ammonia Recovery		
Building A-1		
NH_3/N	4.02	0.770[1]
$NO_2 + NO_3/N$	5.41	0.090[1]
TKN/N	8.18	1.36[1]
Total Solids	3,520	586[1]
Dissolved Solids	3,570	596[1]
Chemical Oxygen Demand	377	62.8[1]
Acid Mixture Distribution		
Hexamine	30	0.109[2]
Nitration Buildings		
Building D-6 (HMX Production)		
COD	22.2	8.42[3]
Total Carbon	5.48	2.08[3]
Organic Carbon	3.44	1.31[3]
Inorganic Carbon	2.04	2.68[3]
Nitrates	$<$0.658	.250[3]
Buildings D-1,2,8 (RDX Production)		
BOD	1,218	7.24[4]
COD	1,440	8.54[4]
RDX	2.63	0.015[4]
HMX	1.05	0.006[4]
Acetic Acid (100%)	200	1.19[4]
Slurry Processing		
Buildings E-2,3,4,8 (RDX Production)		
BOD	206	1.24[4]
COD	10.4	0.063[4]
RDX	9.62	0.058[4]
HMX	0.592	0.004[4]
HAc	511	3.08[4]
TOC	33.8	0.204[4]
Building E-6 (HMX Production)		
BOD	1,460	554[3]
COD	3,260	1,240[3]
RDX	1.38	0.524[3]
HMX	0.90	0.342[3]
HAc	146	55.4[3]
TOC	10.6	4.02[3]

TABLE 32
(continued)

Item	lb/day	lb/ton of product
Recrystallization		
Buildings G-2,3,4,8 (RDX Production)		
BOD	816[6]	4.92[4,6]
COD	424[6]	2.55[4,6]
Organic Carbon	214[6]	1.29[4,6]
Inorganic Carbon	20.1[6]	0.121[4,6]
Cyclohexanone	196[6]	1.18[4,6]
Building G-6 (Specialty Products)		
BOD	376[6]	N.A.[5,6]
COD	1,404[6]	N.A.[5,6]
Organic Carbon	299[6]	N.A.[5,6]
Inorganic Carbon	11.0[6]	N.A.[5,6]
HMX	12.0[6]	N.A.[5,6]
RDX	5.66[6]	N.A.[5,6]
Acetone	91.8[6]	N.A.[5,6]
Cyclohexanone	665[6]	N.A.[5,6]
Toluene	3.06[6]	N.A.[5,6]
Butanol	91.8[6]	N.A.[5,6]
Grinding and Dewatering		
Buildings H-2,3,4,8 (Dewatering Only; RDX Production)		
BOD	3,540[6]	21.3[4,6]
COD	5,480[6]	33.0[4,6]
RDX	62.8[6]	0.378[4,6]
HMX	1.92[6]	0.012[4,6]
Cyclohexanone	182[6]	1.09[4,6]
Acetic Acid	840[6]	5.06[4,6]
Incorporation Buildings		
Buildings I-1,2,9;J-1,2,9;L-1,2,9;M-1,2,3,9		
COD	4,950[6]	1.38[2,6]
RDX	40.3[6]	0.011[2,6]
TNT	81.8[6]	0.023[2,6]
HMX	<13.0[6]	<0.004[2,6]
Organic Carbon	122[6]	0.034[2,6]
Inorganic Carbon	120[6]	0.034[2,6]
Total Carbon	220[6]	0.062[2,6]
Receipt of TNT		
Buildings K-1,3,7		
COD	28.9[6]	0.105[6]
TOC	13.4[6]	0.049[6]
$NO_2 + NO_3/N$	1.21[6]	0.0044[6]
TKN/N	1.38[6]	0.005[6]
Soluble RDX	1.21[6]	0.0044[6]
Soluble HMX	15.7[6]	0.057[6]
TNT	N.A.[5]	N.A.[5]

TABLE 32
(continued)

Item	lb/day	lb/ton of product
Estimated Overall Discharges[2,7]		
NH_3/N	4.02	0.015[2]
$NO_2 + NO_3/N$	7.28	0.026[2]
TKN/N	9.56	0.035[2]
Total Solids	3,520	12.8[2]
Dissolved Solids	3,570	13.0[2]
COD	17,400	63.3[2]
Organic Carbon	638	2.32[2]
Inorganic Carbon	153	0.556[2]
BOD	7,620	27.7[2]
RDX	124	0.451[2]
HMX	45.2	0.164[2]
Acetic Acid	1,700	6.18[2]
Hexamine	30	0.109[2]
Acetone	91.8	0.334[2]
Cyclohexanone	1,043	3.79[2]
Toluene	3.06	0.011[2]
Butanol	91.8	0.334[2]
TNT	81.8	0.297[2]

[1] 12,000 lb/day (6 ton/day) anhydrous NH_3 produced.

[2] 550,000 lb/day (275 ton/day) Composition-B produced.

[3] 5,270 lb/day (2.635 ton/day) HMX produced.

[4] 331,200 lb/day (166 ton/day) RDX produced.

[5] NA = not available.

[6] No correction for feed concentration.

[7] As discussed in the text, these values are of questionable value. At best they represent minimum discharge levels.

TABLE 33
WASTEWATER DISCHARGES FROM AREA B, HOLSTON ARMY AMMUNITION PLANT (2c)

Outfall	Arnott Branch	Process Waste	Process Waste	Process Waste
River Mile	137.9	139.2	139.6	139.7
a. EPA Study of 2-4 April 1973				
Flow, MGD 4/2-4/3/73	30.2	1.17	3.35	1.62
Flow, MGD 4/3-4/4/73	24.5	1.17	3.88	2.68
RDX content, mg/l 4/2-4/3/73	0.35	24	32	Nil
RDX content, mg/l 4/3-4/4/73	0.20	38	15	1.2
b. HAAP RDX Assays, Jan-June 1973				
Mean, mg/l	0.5	6.5	10.4	0.6
Std. Deviation, mg/l	2.4	4.7	6.4	1.4
Minimum, mg/l	Nil	Nil	Nil	Nil
Maximum, mg/l	11.2*	12.8	24.3	4.3
c. HAAP HMX Assays, Jan-June 1973				
Mean, mg/l	0.2	2.1	2.6	0.1
Std. Deviation, mg/l	0.9	2.3	2.6	0.3
Minimum, mg/l	Nil	Nil	Nil	Nil
Maximum, mg/l	4.4*	7.5	8.9	1.4*
HMX content for purposes of overall estimate, mg/l	†	4.4	5.2	0.4

*Only one grab sample for six month period indicated explosive content.
†Not used due to isolated occurrence.

30. NITROGUANIDINE (NGu)

NGu ($H_2NC(NH)NHNO_2$) is of particular interest as an explosives waste because it is more soluble in water than most explosives (4.4 g/l at 25°C).

NGu is used only as a component of M30 triple base propellant (the other components being nitrocellulose and nitroglycerin), which is used for 76 mm, 90 mm, and 105 mm tank-fired artillery rounds (15k). In FY 73, 11,500,000 lb of this propellant were produced at RAAP (151). The NGu content of M30 propellant is 47.7 percent, hence some 5,500,000 lb of NGu was used. (2c).

At present, NGu is purchased from Cyanamide LTD of Canada (15k). A NGu production facility with 30,000,000 lb/year capacity is planned for operation at Sunflower Army Ammunition Plant (SAAP), KS by September 1978(15k). The British Aqueous Fusion Process has been selected to manufacture this material. In this process, guanidine nitrate is produced from urea and ammonium nitrate in the presence of a silica bead catalyst. Guanidine nitrate is subsequently converted to nitroguanidine bisulfate by dehydration in concentrated sulfuric acid. The nitroguanidine is precipitated from the reaction solution by adding water. After the resulting weak acid solution has been filtered off, the NGu is further purified, dried, and packaged (3q).

The nitroguanidine facility at SAAP will be designed so that no explosives-bearing discharges to surface streams occur. Discharges from fume scrubbers and accidental dumps (the most likely source of which are from material cleaned out of plugged pipelines) will be contained in concrete-lined pits. These wastes, depending on their source, would be either burned or recycled for processing (2c).

31. PRODUCTION OF NITROGLYCERIN (NG)

a. Process Description

Nitroglycerin, or more correctly glyceryl trinitrate, is made by adding glycerol in a batch or continuous process to a mixture of concentrated nitric and sulfuric acids. Agitation and external cooling keep the temperature below 25°C. When reaction is complete, the residual acid phase is decanted and the product is washed with aqueous sodium carbonate solution and water (2b).

Currently, nitroglycerin is made at BAAP and at RAAP. BAAP employs a batch process, while a continuous process is used at RAAP. Nitroglycerin is a principal ingredient of double-base and triple-base propellants (combined with nitrocellulose in double-base; with nitrocellulose and nitroguanidine in triple-base), which are formulated at the two plants. Monthly production is now 205,200 lbs at BAAP and 500,000 lbs at RAAP. The maximum potential monthly production figures are 2,250,000 lbs for BAAP, 2,500,000 lbs for RAAP, and 3,600,000 for Sunflower Army Ammunition Plant (inactive) (2b).

The reader is referred to Chapter IV of this report for a more detailed discussion of process.

b. Water Use and Wastewater Volume

(1) Water Use

(a) BAAP. In the batch process manufacture of NG at BAAP, approximately 0.05 gallon of process water is used per pound of NG produced (9a). This amounts to a process water requirement of 1,280 gpd at a production level of 25 percent of capacity (12.8 ton/day). Note that this does not include cooling water. If total wastewater discharge at this level of production is roughly 110,000 gpd, then the cooling water requirement is about 109,000 gpd.

(b) RAAP. At RAAP, two NG production areas exist. NG Area 1 is currently inactive. NG Area 2 employs the Biazzi Process (continuous), and currently produces approximately 17,000 lb/day NG. Approximately 50,000 gpd of water are used in the process (6a). Note that this figure includes cooling water requirements.

(2) Distribution of Wastewater Volumes

(a) BAAP. Measurements made when NG production was at 25 percent of capacity at BAAP indicated a wastewater flow of 120,000 gpd (2b) (Note that the figure used in this report is 110,000 gpd -- see Table I .J.1). Compressor cooling waters from the compressed air agitator and refrigeration systems are mixed with the NG process wash waters. All waste streams eventually drain into two ponds from which the pollutants present can leach into the ground.

(b) RAAP. Nitroglycerin is manufactured in Nitroglycerin Area No. 2. In the Nitration Building, glycerin is nitrated by mixing and reacting with nitric acid. Oleum (concentrated sulfuric acid) is used as a dehydrating agent to remove a portion of water formed during the nitration process. Wastewaters generated here consist of soda ash wash and freshwater wash, as well as washdown water and some acid, which is drawn off from the process and neutralized (1n(3)).

The processed NG is placed in a storehouse until needed for propellant manufacture. At the storehouse, NG is placed in tanks and excess water drained off to a specified level. This water goes to a catch tank and then to an open gutter for discharge. When needed the NG is sent to the NG Mixhouse for combination with various solvents prior to premixing. Wastewaters generated here are from mixing tank washout and floor washdowns (1n(3)).

The NG proceeds to the Premix Building which is utilized for mixing NC, NG, and certain other stabilizing compounds. Wastewaters from this building result solely from washdown of floors and equipment. A Slurry Mix Building is also often used for mixing, in a slurry form, nitrocotton, NG, and stabilizing compounds (1n(3)).

All wastewaters from the NG Area No. 2 and Premix Area No. 2, after passing through catch tanks, empty into open gutters, and are discharged subsequently to the New River without further treatment (1n(3)).

Currently, catch basins are the only treatment provided before the nitroglycerin waste streams empty into the New River.

Table 34 summarizes NG wastewater sources at RAAP. The discharges which can be calculated from the given flows and concentrations have not been used in calculating the overall discharges presented in Table 36.

Table 35 compares the wastewater volumes generated at BAAP and RAAP. The continuous process employed at RAAP is only slightly more efficient in terms of wastewater generated than the batch process used at BAAP.

c. Qualitative and Quantitative Aspects of the Liquid Wastes

(1) BAAP. Tables I.J.1 and 36 fairly well summarize the character of the wastewater from NG production at BAAP.

The wastewater from this area is characterized by a low pH (range 1.7-9.5, average 4.7) and significant concentrations of nitrate (range 0.5-200 mg/1, average 117 mg/1) and sulfate (range 62-415 mg/1, average 240 mg/1). Occasional discharges of sodium carbonate solutions used to neutralize residual acids in the nitroglycerin raise the pH to 9.5. The pond which accepts all wastewater flow from the Nitroglycerin Plant has a sandy bottom and all flow percolates to groundwater. The pH is not low enough, and the nitrate and sulfate concentrations are not high enough to present a groundwater pollution problem. There are no wells producing water used for human or livestock consumption in nearby areas (1a(2)).

(2) RAAP. Wastewater characteristics for NG production at RAAP are detailed in Tables I.J.2 through I.J.8, 35, and 36.

Evaluation of results reveal that the largest concentration of contaminants, principally in the form of dissolved solids, nitrates, sulfates, and NG, come from the wastes generated at the Nitration Building. Concentration of dissolved solids was as high as 70,000 mg/1 in one sample. The major source of the dissolved solids is from the neutralization with soda ash of waste acid released from the Nitration Building. The high concentrations in samples were particularly noticeable for eight-hour composite samples collected over periods during the operation of the Nitration Building. This was noted from large deviation from mean concentrations, especially for NO_2-NO_3/N and dissolved solids. Approximately 3600 pounds of dissolved solids, 210 pounds of NO_2-NO_3/N, and 47 pounds of NG were being discharged daily to the New River from the combined effluent. Concentrations of dissolved solids and NO_2-NO_3/N were also significant in wastewaters being discharged from the Mixhouse (1n(3)).

Small metal catch basins are provided for settling out NG at effluent lines from the Nitration Building, Storehouse, Mixhouse, and Premix Buildings. Observation of these catch basins revealed little accumulation of solids (1n(3)).

Note that acid wastes have been neutralized prior to gathering the wastewater data from RAAP (see Tables I.J.2 through I.J.8) while such was not the case with BAAP (see Table I.J.1).

d. The Effects of Process Change on Wastewater Volumes

(1) BAAP. The Biazzi continuous process for manufacturing NG is scheduled to replace the present method at BAAP. It is anticipated that this will decrease somewhat the amount of process wastewater, and thereby perhaps reduce the NG output in the wastes (since these waters are generally saturated with NG).

(2) RAAP. An oil separator (gravity type) will be installed to reduce the oil released by washdown of the compressors. In addition, an ion exchange resin (Duolite ES63) may be employed to remove lead from the NG nitrator wash- and slurry mix waters (6a).

A 60 percent reduction in water usage has also been proposed (PE 290). This will be accomplished by recirculating water from the: air compressor house, store house, transfer line heat, and separator.

e. Data Limitations

Data on the solids content of wastes from the current batch process at BAAP would have proved extremely useful in the present study.

TABLE 34
NITROGLYCERIN WASTEWATER SOURCES AT RADFORD ARMY AMMUNITION PLANT (6b, 6c, 1n(3))

Source	Flow (gpd)	COD (mg/1)	NO_3^-(N) (mg/1)	Sulfate (mg/1)	Nitroglycerin	
					(mg/1)	(1b/day)
Nitrator	2,500	1,228	13,280	1,416	1,300	27
Air Compressor	15,000	72	3	28	Nil	Nil
Spent Acid	20,000	22	433	760	Nil	Nil
Store House	2,500	912	477	130	266	6

TABLE 35
WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF NITROGLYCERIN

	RAAP	BAAP
MGD	.064	.110
Gal per Ton of Final Product	6,520[1]	8,590[2]

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[1] 19,600 lb/day (9.8 ton/day) NG on continuous process basis

[2] 25,600 lb/day (12.8 ton/day) NG on batch process basis

TABLE 36
OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF NITROGLYCERIN

AAP Parameter	RAAP		BAAP	
	Discharge (lb/day)	Discharge (lb/ton of product*)	Discharge (lb/day)	Discharge (lb/ton of product*)
TKN/N	.724^1	.073	.238^3	.018
NH_3/N			.843^3	.066
NO_2+ NO_3/N	208^1	21.2	106^3	8.28
PO_4/P			.531^3	.041
SO_4	68.3^1	6.97	187^3	14.6
COD	48.4^1	4.94	58.7^3	4.58
TOC	40.8^1	4.16	7.60^3	.594
Pb			0.669^3	.052
Fe				
Acidity (as $CaCO_3$)	.006^1	.001		
Alkalinity (as $CaCO_3$)	1080^1	110		
Total Solids	4030^1(2120)^2	411(216)		
Suspended Solids	3.29^1(.359)^2	.336(.037)		
Dissolved Solids	4030^1(2120)^2	411(216)		
NG	47.7^1	4.87	13.7^4	
Volatile Solids	(416)^2	(42.4)		
HNO_3			5120^4	
H_2SO_4			256^4	

*19,600 lb/day (9.8 ton/day) NG
**25,600 lb/day (12.8 ton/day) NG
[1] Reference (j.5)
[2] Reference (j.6)
[3] Reference (j.2)
[4] Reference (j.1)

32. PRIMER COMPOUNDS

A primer is a mixture of explosives and ignitable chemicals which initiates a sequence of increasingly powerful detonations which lead to the bursting of a charge or the ignition of a propellant. The explosives used are generally very sensitive to shock or impact. The most widely used small arms primer mixtures and their compositions appear in Table 37. Of these compounds, TNR, lead styphnate, tetracene and PETN are discussed in detail in this section. TNR is of interest not only as a primary ingredient but as the precursor of lead styphnate, the major explosive constituent of the primer mixtures in Table 37. PETN has been used as a shaped charge ingredient (mostly in a 50% PETN-50% TNT mixtured called "pentolite"), but other explosive mixtures have replaced it (15m). PETN is used to a limited extent in boosters and detonators (15m). However, the amounts involved are believed small compared with primer requirements, and PETN will be discussed only in terms of its use in the primers of Table 37. The structures of the various primer ingredients appear in Figure 4.

a. Production Methods and Wastewaters Generated

Figure 5 is an overall flowsheet of primer composition and use, and indicates where wastewaters are generated. The discussion is restricted to methods employed at Lake City Army Ammunition Plant (LCAAP), Independence, Missouri, which is currently the only AAP where primers are handled. In October, 1973, the primer facilities of the Twin Cities Army Ammunition Plant (TCAAP), Minneapolis, Minnesota, were placed in stand-by status (2c). Data on PETN production was unavailable.

(1) TNR. To produce TNR, a 30-lb batch of resorcinol is first mixed with 240 lb of 98% sulfuric acid (15.o). Then 72 lb of 95% nitric acid is added to the crude resulting mixture of resorcinol-4,6-disulfonate

in sulfuric acid. (15p) The crude TNR is removed from the spent acid and pooled with two other TNR batches. The batches are washed with about 100 gallons of 1 N nitric acid to remove traces of sulfate and filtered (15p). The acids from all these processes are collected in a sump and treated with sodium carbonate solution. Once a week, the collected TNR sludge is treated with a mixture of 30 lb sodium hydroxide and 20 lb powdered aluminum (15q). The resultant degraded sludge is a black, possibly polymeric material. The neutralized acids and the treated sludge are routed to a series of wastewater evaporation lagoons (2c).

Lake City AAP personnel indicate that about 60 lb TNR is produced per 30 lb of resorcinol charge (15q). This is about a 90% yield; smaller scale TNR production (a slightly different process) at Frankford Arsenal, Philadelphia, Pennsylvania, has resulted in 76% yields (15n). Their product has been analyzed and found to be 93.5% TNR (11a). The identified impurities include a 1:1 TNR-dinitroresorcinol addition product (0.8%), dinitroresorcinol (1%), 6-nitroso-2-resorcinol (1%), 2-nitroresorcinol (0.5%), and mesoxalic acid oxime* (0.2%). On the basis of 90% conversion at LCAAP, about 6 lb of TNR is lost per batch produced. With a solubility of the order of 7 g/l, some of this TNR could be washed out with the 1N nitric acid washes and be discharged to the evaporation pond as the sodium salt of TNR (2c).

(2) Lead Styphnate. Two "master solutions" are prepared for lead styphnate synthesis, the first a 720-liter solution of 130 lb TNR and 21 lb magnesium oxide, the other a 150-liter solution containing 100 lb of lead nitrate (15q). Seventy liters of the first solution are mixed with 26

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*$OH-N=C-(COOH)_2$. It is formed from cleavage of the ring and oxidation of the end hydroxyl groups (2c).

liters of the second, whereupon lead styphnate precipitates. The spent solution with product is drained through 50 mesh screen on which the product is collected. The spent solution is neutralized (the solution becomes acid as the reaction progresses) with sodium carbonate. The lead styphnate is washed several times, the washwater from each wash being removed by vacuum. These washwaters and spent solution are routed to storage tanks. Once daily, sodium hydroxide and aluminum powder are added to these tanks, and the contents steam boiled. The contents of the tanks are then discharged to a series of evaporation lagoons, different lagoons from the ones used for TNR disposal (2c).

About 19 lb of lead styphnate are produced per batch (15q), which indicates 79% yield. The remaining 21% of yield, or about 5 lb of lead styphnate, is lost per batch (2c).

(3) Tetracene. To produce tetracene, a 65 liter solution of 26.2 lb aminoguanidine bicarbonate in dilute sulfuric acid is mixed with 15 liters of solution containing 22.5 lb sodium nitrite (15q). Tetracene precipitates, and its further processing is similar to that used for lead styphnate. However, the collected mother liquors (previously neutralized with sodium carbonate) and washwaters are simply boiled after collection. The wastes are then routed to the lead styphnate lagoons. The tetracene yield is about 16 lb/batch (15q), which indicated 87% conversion. It is assumed that the remainder is lost product, or about 2.4 lb tetracene/batch. This tetracene would be readily decomposed by boiling to the substances mentioned above (2c).

(4) Primary Mixtures. Because of their high explosive sensitivity, primer mixtures are prepared in small quantities and used rapidly after preparation. To prepare the primers listed in Table 37 screened ingred-

ients are mixed in a blender. There is no definitive breakdown of primer losses in formulation or use. Lake City AAP supervisory personnel estimate that about 12% of the amount of primer used in small arms ammunition is wasted (15n). This percentage represents primer material cleaned out from screens and blenders, spills, unused or dried-out mixtures, and washdowns. The wastewaters with primer ingredients are dosed with sodium hydroxide and aluminum powder and then heated. The primer-desensitized wastewaters are then routed to the LCAAP industrial wastewater treatment plant (IWTP) where they contact other wastes from LCAAP activities (15q). The IWTP treatment at LCAAP consists of aeration, with subsequent skimming to remove oils and greases, dosing with alum and lime to adjust pH and promote flocculation, and settling of solids from effluent prior to discharge to surface flow (2c).

b. Qualitative and Quantitative Aspects of the Wastewaters Generated

The magnitude of primer waste loading to lagoons and the IWTP at LCAAP may be estimated on the basis of round production, the 12% waste factor, batch sizes, and estimated losses from batch productions cited previously. The computations involved are summarized in Table 38 for LCAAP production for September-December, 1972 (15r). The primer consumptions reported in the first footnote of Table 38 were determined from the Technical Data Packages of the rounds involved and are mean or nominal weights. The nominal daily primer loading routed to the IWTP is about 18 lb/day, which consists of about 16 lb of lead styphnate, about 1.5 lb each of tetracene and PETN, and a trace of TNR. The nominal daily primer waste loading that would be routed to lagoons is about 50 lb/day, of which 38 lb is lead styphnate, 10 lb is TNR and 2 lb is tetracene (2c).

The wastewater associated with TNR production cited in Table M.2 is about 500 gallons/day. An additional 700 gallon dump containing treated TNR sludge is added once a week. This wastewater is routed to lagoons, and once every few years the sludge therefrom is removed to a landfill (15q).* The lagoons and the landfill sites are located on a substratum considered relatively impervious to seepage from the lagoons to groundwater (1i(2)). Some dissolved TNR, probably occurring as the sodium salt, may be present in lagoon wastewaters. The components of the TNR sludge have not been characterized. One proposed end product is phenylenetriamine (15n), and polymeric products featuring amine linkages between phenyl groups may also occur. (2c).

About 1500 gallons/day of wastewater discharges are associated with the lead styphnate and tetracene production cited in Table 38. These wastewaters are routed to lagoons (a different set from those used for TNR waste) which are infrequently cleaned of sludge. Lead styphnate should undergo decomposition to inorganic lead salts and the organic species formed from TNR decomposition. The tetracene decomposition products should initially be in the form of those generated in the boiling water treatment of tetracene. However, in the basic environment of the lagoons, the 5-aminotetrazole and 1-H-tetrazole should be converted to basic salts. The relative amounts of these tetracene decomposition products have not been determined (2c).

The wastewaters associated with LCAAP primer preparation and use (Table 38) are about 5000 gallons/day. This wastewater would contain the decomposition products of the primer ingredients. The primer wastewater loading to the IWTP is about 0.5% of the total input to the IWTP as determined by the USAEHA Survey of 1971 directed by Graven (1i(2)). The fate of primer wastes proceeding through the IWTP would depend to a large extent upon the solubilities of the decomposition products, which are generally unknown (2c).

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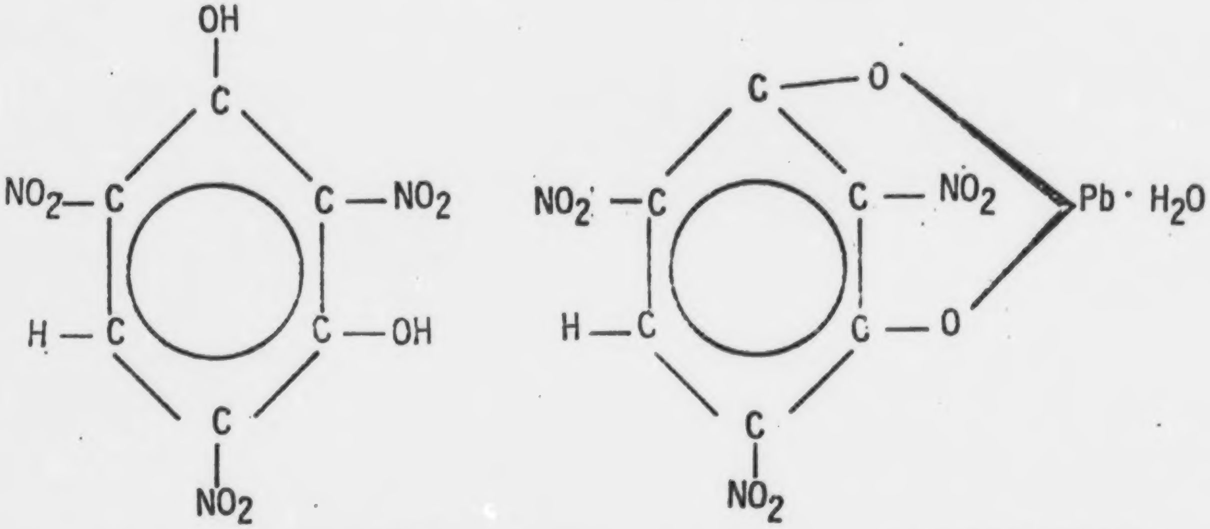
*Sludge is removed from these lagoons only when the lagoons actually dry out. Recent wet weather at LCAAP has been filling up the lagoons faster than evaporation can remove water (15q).

The production levels indicated in Table 38 are, in terms of full capacity, by round size: 5.56 mm rounds, 74%; 7.62 mm rounds, 35%; 30 Caliber M1 rounds, 49%; 30 Caliber Carbine rounds, 100%; 50 Caliber rounds, 3%; and 20 mm rounds, 51%. Production levels and attendant pollutant discharges are subject to change. One indication of this can be inferred from an analysis of primer production on the basis of raw material purchases. In 1971, purchases of raw materials of interest were: resorcinol, 8200 lb; lead nitrate, 21,000 lb; aminoguanidine bicarbonate, 5,000 lb; and PETN, 2,000 lb (m.10). From the production methods discussed, the nominal monthly production of primer ingredients and their comparison to Table 38 estimates are: TNR, 1,366 lb vs 2,880 lb; lead styphnate, 1,920 lb vs 4,290 lb; tetracene, 246 lb vs 530 lb; and PETN, 167 lb vs 414 lb. Presuming no accumulation or depletion of inventory, late 1972 production was generally more than double that indicated from 1971 purchases (2c).

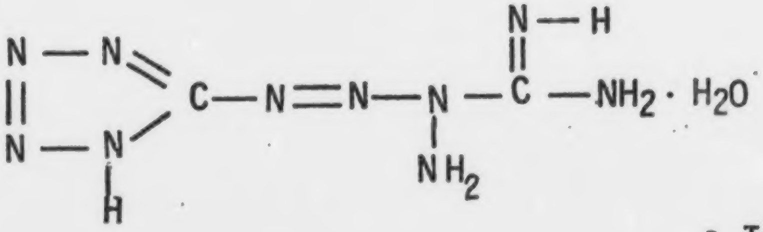
The situation at TCAAP merits review since demilitarization of existing primer ingredient stocks is being done due to the switch to standby status (15t). At TCAAP, TNR was purchased from commercial sources, so any TNR-derived wastes would come from the demilitarization of stock. All other wastewaters from primer ingredient preparation, primer mixing, and use were diverted to one lagoon. This lagoon is underlaid by sandy porous soil into which water leaches. In the USAEHA survey report issued in 1973, Kirmeyer (1q(1)) recommended monitoring for potential lead leaching by drilling observation wells. During plant operation, the lagoon wastes were normally alkaline (pH of 10 or higher), hence lead salts would be insoluble. However, dilution of lagoon water with rain or snow, especially under standby conditions, could change this situation.

FIGURE 4
MOLECULAR STRUCTURES OF PRIMER COMPOUNDS (2c)

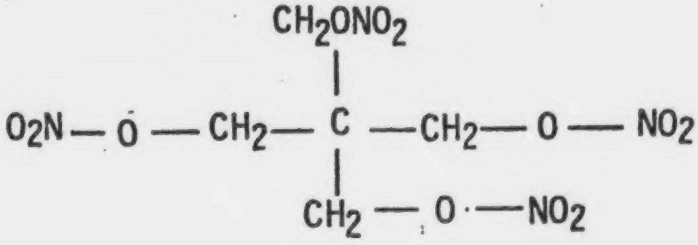


a. TNR

b. Lead Styphnate



c. Tetracene

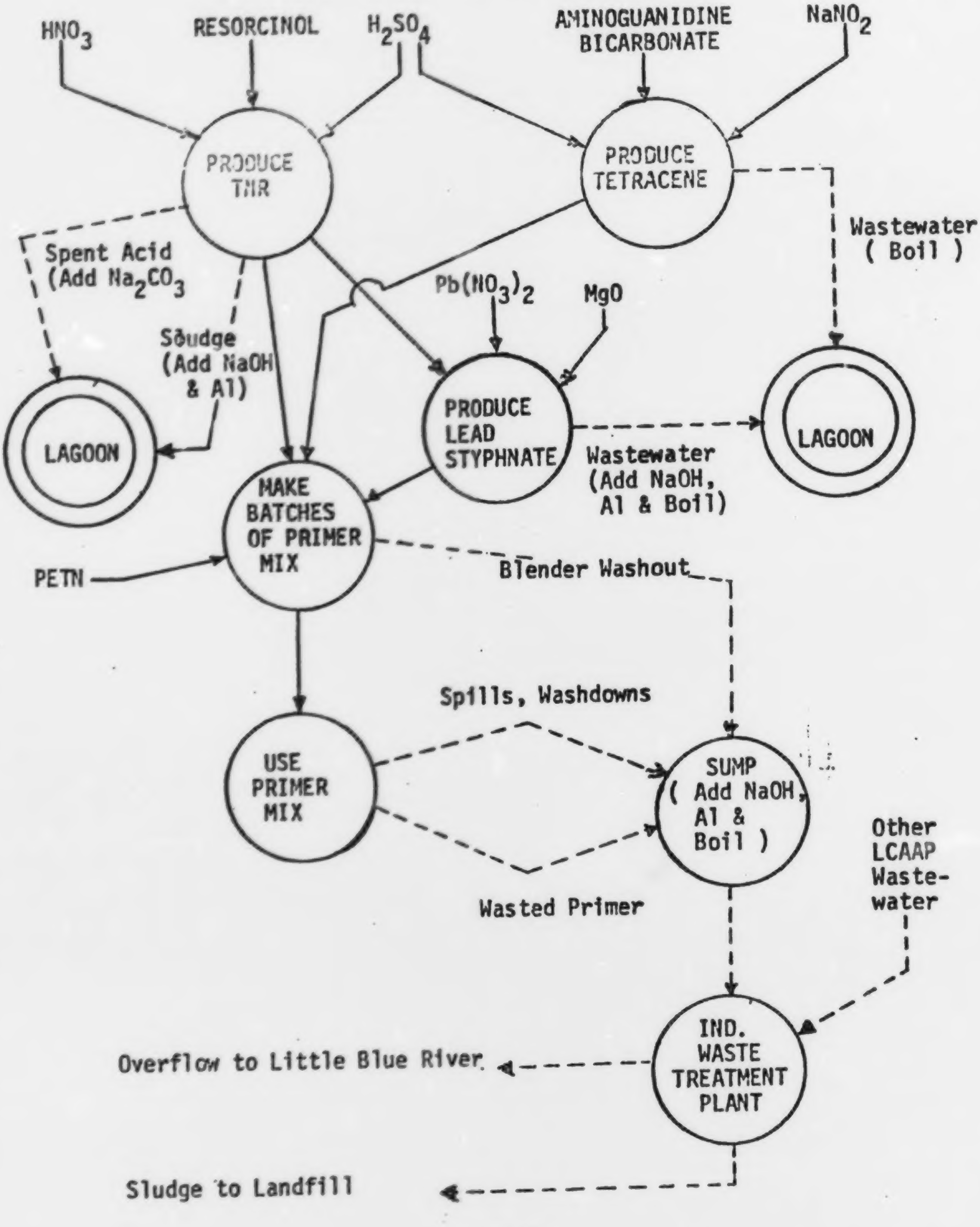


d. PETN

TABLE 37
PRIMER MIXTURES AND COMPOSITONS (15n)

PRIMER DESIGNATION	FA 874	FA 956	5061W	5067W
Ingredient	Percent of Cited Ingredient in Primer Mixture			
Lead Styphnate	40	37	38	38
Tetracene	--	4	2	2
PETN	--	5	--	--
TNR	1	--	--	--
Barium Nitrate	44	32	43.5	60
Antimony Sulfide	--	15	9	--
Aluminum	--	7	7.5	--
Others	15	--	--	--

FIGURE 5
FLOWSHEET OF PRIMER MANUFACTURING AND WASTEWATER TREATMENT AT LAKE CITY ARMY AMMUNITION PLANT (2c)



HNO_3
RESORCINOL
H_2SO_4
AMINOGUANIDINE BICARBONATE
$NaNO_2$
PRODUCE TNR
PRODUCE TETRACENE
Wastewater (Boil)
Spent Acid (Add Na_2CO_3
Sludge (Add NaOH & Al)
$Pb(NO_3)_2$
MgO
LAGOON
PRODUCE LEAD STYPHNATE
LAGOON
Wastewater (Add NaOH, Al & Boil)
MAKE BATCHES OF PRIMER MIX
PETN
Blender Washout
Spills, Washdowns
USE PRIMER MIX
SUMP (Add NaOH, Al & Boil)
Other LCAAP Wastewater
Wasted Primer
IND. WASTE TREATMENT PLANT
Overflow to Little Blue River
Sludge to Landfill

TABLE 38
SMALL ARMS PRODUCTION, ESTIMATED PRIMER CONSUMPTION AND LOSSES AT LAKE CITY ARMY AMMUNITION PLANT SEPTEMBER-DECEMBER, 1972 (15r)

Item	Production 10^6 rounds/mo	Primer	Primer Use lb/mo*	Use of Primer Component, lb/mo			
				TNR	Lead Styphnate	Tetracene	PETN
5.56 mm Ball	93	FA 956	4520	---	1670	180	230
7.62 mm Ball	24.5	FA 956	1890	---	700	80	90
30 Caliber Ml	13.0	FA 956	1000	---	370	40	50
30 Caliber Carbine	12.0	5067 W	580	---	220	10	---
50 Caliber	0.2	5061 W	64	---	24	1	---
20 mm	5.7	FA 874	2130	21	850	---	---
Total amount used for primer fills, lb/mo				21	3834	311	370
Estimated waste sent to IWTP (12% of above)				3	460	37	44
Sum of above (estimated monthly production)				24	4290	350	Purchase
Batches needed for estimated monthly production				48†	226	22	---
Estimated loss of explosive from batch production (sent to lagoons)				288	1150	57	---

*Primer usage expressed in pounds per million rounds based on nominal or mean loadings are: 48.6 lb for 5.56 mm rounds, 77.1 lb for 7.62 mm or 30 Caliber MI rounds, 48.6 lb for 30 Caliber Carbine rounds, 321.4 lb for 50 Caliber rounds, and 374.3 lb for 20 mm rounds.

†Includes TNR required for lead styphnate production.

33. NITROCELLULOSE (NC) PRODUCTION

Nitrocellulose is not readily biodegraded in water. However, its insolubility and probable ease of removal therefrom by coagulation and/or filtration make it unlikely that this material will pose a serious toxic hazard. It is only its relatively high rate of discharge into receiving waters that gives NC such high priority in studies of munitions industry wastes.

a. Process Description

The reader is referred to Chapter IV of this report for a detailed discussion of the production processes.

Nitrocellulose, more properly called "cellulose nitrate," is made by treating cotton linters or wood pulp cellulose with mixed nitric and sulfuric acids at 30-34°C for about 25 minutes. After this, the material is wrung and "drowned" in water to remove most of the acid. The crude product, containing roughly three nitrate ester groups per glucose unit, is subjected to prolonged treatment (about 70 hours) with boiling dilute sulfuric acid. Following this, it is cut and beaten in a large volume of slightly alkaline water to remove residual acid and reduce the average fiber length. It is then poached, i.e., treated with several changes of boiling water, washed, and screened to remove most of the water. During the post-nitration processes, some of the less stable ester groups are removed; thus, even the most highly nitrated form of nitrocellulose used, guncotton, has a maximum nitrogen content of 13.55%, while three nitrate ester groups would give an analysis of 14.1% nitrogen (and two would show 11.1% nitrogen). The purification process removes unstable impurities, such as cellulose sulfate and nitrates of oxidized cellulose. (Quite likely, there is no cellulose sulfate as such, but random sulfate ester groups are removed from crude nitrocellulose.) (2b).

Currently, nitrocellulose is made only at RAAP and BAAP. Both make single and double base propellants, and RAAP also makes triple base propellant. At RAAP, nitrocellulose production is now 5,000,000 lbs per month, and could be raised, with existing facilities, to 12,000,000 lbs per month. Producton at BAAP is 2,700,000 lbs per month with a maximum potential of 16,300,000 lbs per month. Indiana, Sunflower, and Alabama Army Ammunition Plants, presently inactive, have potentials for 24,000,000 lbs, 9,300,000 lbs, and 12,000,000 lbs per month, respectively (2b).

b. Water Use and Wastewater Volume

(1) Water Use. Batch NC production requires a large amount of process water (16 to 22 gallons/lb nitrocellulose produced) (2b). This corresponds to 38,000 gallons per ton of final product. Current water usage at RAAP is 4,750,000 gpd or 72,519 gallons/lb of NC produced. Water usage figures for BAAP were not available.

(2) Distribution of Wastewater Volume. Table 39 summarizes the wastewater volumes generated in the production of NC at RAAP and BAAP. Note that solvent recovery (alcohol rectification) operations have also been included. Note also that the volume of wastewater generated in each case far exceeds the 38,000 gallon per ton of final product water usage figure reported by USAMEERU (2b). This would tend to discredit the validity of that figure. It should be added that the effluent volumes listed in Table 39 were arrived at by summing flow tabulated in Tables I.I.1 through I.I.32, and there is good reason to doubt the completeness of this data (e.g., see conflicting data presented in Table 40 which is also based on Tables I.I.1 through I.I.32).

At BAAP, nitrocellulose acid wash water and boiling tub washwater drain to a settling sump where nitrocellulose fines are removed. Overflow from the sumps flows to waste acid neutralization facilities at each line, where lime slurry is added to neutralize the acids present. The flow of lime slurry is controlled by a feed back pH controller. Waste from the acid neutralization facilities flows to the industrial waste sewer. Water from nitrocellulose washing, beating, and blending, flow to "poacher pits" where nitrocellulose fines settle out. The effluent from these pits is either recycled to the wash lines, or overflows to the industrial waste sewer (1a(1)).

At RAAP, acid wastewater generated from washing the NC after each process step in the Boiling Tub House is diverted through a closed drain system to the Boiling Tub Settling Pits. These are large rectangular concrete pits, lined with acid resistant bricks. Neutralized wastes which flow from the Jordon Beater House, the Poacher-Blender House, and Final Wringer House are also carried through a closed piping system to another set of pits. Much of the NC carried in the drain water settles to the bottom of the pits. At scheduled intervals this accumulation of NC fines is pumped back into the system and used as "pit cotton" when making up blends which contain both "Low Grade" (LG) and "High Grade" (HG) NC. Some fines are lost in pit overflow and some escape to the New River after flowing through the A/B-line Waste Acid Neutralization Facility (1n(3)).

c. Qualitative and Quantitative Aspects of the Liquid Wastes

(1) BAAP. Acid wastes are the biggest problem posed by the production of NC at BAAP. The wastewater flow to the acid neutralization plants is characterized by extremely low pH (range 0.4-3.3, average 1.4), high sulfate concentrations (range 75-5100 mg/1, average 2600 mg/1), high nitrates (range 100-1350 mg/1, average 700 mg/1), and fairly high concentrations of COD (range 80-650 mg/1, average 185 mg/1). The low pH and high concentrations of sulfates and nitrates are expected from the washing of entrained

acid from the crude nitrocellulose, and the fairly high concentrations of COD are most likely due to dissolved and suspended cellulose and nitrocellulose in the wastewater. No other contaminants appeared to be present in significant quantities (1a(2)).

The wastewater flow from the acid neutralization plants is characterized by widely ranging pH (range 0.9-12.4, average 9.4) and high concentrations of nitrate (range 50-600 mg/1, average 400 mg/1) and sulfates (range 100-3000 mg/1, average 1350 mg/1). The acid neutralization plant uses lime for neutralization which reacts with the sulfates present to form the slightly soluble salt, calcium sulfate. As the calcium sulfate particles form, some nitrates and other materials are entrained in the particle structure. Although no facilities for removal of these solids exist at the neutralization plant, the methods of analyses used required filtration of samples, thus showing some reduction in sulfate and nitrate concentrations. The extremely high pH values are due to the location of the pH measuring probe and the type of controlling equipment. The pH measuring electrode is placed quite close to the lime addition equipment. Because lime requires 102 minutes for complete reaction and the pH measuring probe is only 2-3 seconds downstream from the point of lime addition, the pH control equipment feeds lime at a much greater rate than is necessary. Consequently, when the reaction is complete, the pH is much higher than the 6.5 set point on the controller. Lime and calcium sulfate deposits on the mixing apparatus build up quickly, so to avoid complete shutdowns for cleaning, the lime feeders are locked off for 4-6 hours per day to allow the strong acids in the stream to clean those deposits from the equipment. When the lime feeders are locked off, the pH drops to equal the influent pH. A study by BAAP personnel to determine possible methods of modifying the existing acid neutralization equipment to provide more effective pH control has been conducted (1a(2)).

The characteristics of the wastewater from the two "Poacher Pits" differed considerably during the 1970 USAEHA study (1a(2)). The "Poacher Pits" had not been cleaned for an extended period, and operational difficulties in the "C" line nitrocellulose washing process were being encountered. The wastewater from "B" line "Poacher Pit" is characterized by high COD concentrations (range 43-2100 mg/1, average 750 mg/1) and high TOC concentrations (range 29-720 mg/1, average 320 mg/1) with low suspended solids (range 0-13.6 mg/1, average 7.6 mg/1). These data indicate that considerable concentrations of soluble organic compounds are in the wastewater. These organic compounds may be from powder blocks rejected in the Greenline Nitrocellulose Area and recycled. It could not be determined during the survey if any studies had been performed to determine alternate methods of recycling these rejected powder blocks. The wastewater from the "Poacher Pit" in the "C" line area was characterized by significant pH fluctuations (range 1 5-6.9, average 5.4) and high suspended solids. The pH fluctuations are caused by operational difficulties in the nitrocellulose washing process. These difficulties were temporary and were expected to be eliminated shortly thereafter. The high suspended solids (range 64-140 mg/1, average 105 mg/1) are presumably caused by the buildup of solids in the pit. This difficulty was expected to be resolved by scheduled cleaning of the pit shortly after the survey (1a(2)).

All contaminated wastewater from the greenline nitrocellulose area except that from solvent drying is pumped to the settling basin in the nearest nitrocellulose line. Wastewater from solvent drying of smokeless powder is pumped to the solvent recovery area.

Tables I.I.1 through I.I.5 present detailed analyses of the major waste streams from the NC area at BAAP as determined by a later USAEHA study (1a(1)). Overall discharges resulting from the production of NC at BAAP are presented in Table 40. It appears that pollutant discharge per ton of final product is somewhat higher at BAAP than at RAAP. Considering that the wastewater volumes generated at BAAP are also somewhat higher, it may be that the apparently more efficient process at RAAP is due to a somewhat greater degree of recycle at this plant. Both plants utilize batch operations.

(2) RAAP. Suspended solids in the NC Area wastewater drain lines can be assumed to at least approximate NC fines being lost. Suspended solids increased significantly from small losses in the Boiling Tub House of approximately 150 lbs/day to average daily losses of approximately 650 lbs/day in the Jordon Beater House and 650 lbs/day from the poaching operation. This amounts to approximately 45 pounds lost in the drain of a single tub in the Jordon Beater House and 91 pounds per 24,000-pound batch of NC processed in the building, and 126 pounds of suspended solids lost per batch of NC processed in the poacher operation (1n(3)).

Highest concentrations of NO_2-NO_3/N were noted in wastewater samples collected from the initial fill and drain operation in the Boiling Tub House amounting to a loss of approximately 830 pounds per batch of NC processed. Higher specific conductance as well as total organic carbon concentrations were also noted in the samples. Wastewater samples from initial process steps were highly acidic as expected, and samples taken from later steps were neutral or slightly alkaline in nature.

Detailed analyses of the waste streams generated in the NC and alcohol rectification areas are presented in Tables I.I.6 through I.I.32. Overall discharges resulting from the production of NC at RAAP are presented in Table 40.

d. The Effects of Process Change on the Wastewaters

(1) BAAP. A good deal of the process water management technology to be employed at BAAP in the future will be derived from the model study being conducted at RAAP. The most recent process change affecting the character of NC liquid wastes was a purification facility scheduled for completion in 1973. This facility will reduce acid wastes and suspended nitrocellulose fibers; however, the extent of this reduction is unknown.

(2) RAAP. Switchover to a more or less continuous NC production process with recycle is expected to reduce water usage from 4,750,000 gpd to 200,000 gpd (6a). Nitrocellulose fines separation illustrates the type of process that will be employed to implement recycle. Wash water will be passed through centrifuges as it flows from purification vessels to remove the solid particles to be returned to the process. The clarified water will be reused to the extent possible with the remainder being discharged to the A/B-line waste neutralization facility. It is estimated that 50 percent of the effluent from the use of centrifuges can be recycled. Presented below are results from the Delaval Centrifuge pilot study (6a).

Effluent Flow	Test Results	NC Content	Clarified Effluent
	Boiling Tub Pit	188 ppm	
8420 gph	Poacher Pit	477 ppm	25 ppm
9000 gph	Tail Waters	230 ppm	25 ppm
Average flow rate from centrifuge = 8000 gph			

The centrifuges will be located at the end of the settling pits in the purification area. Fines will be recycled also.

e. Data Limitations

Poor agreement exists among results from various analytical studies of the wastes from NC production at these two plants. This is particularly true of RAAP.

TABLE 39

WASTEWATER VOLUMES GENERATED IN THE PRODUCTION OF NITROCELLULOSE

	RAAP	BAAP
MGD	2.96[1]	7.07[4]
Gal per Ton of Final Product	45,200[2]	157,000[3]

[1] .87 mgd of this is generated in the alcohol rectification process

[2] 131,000 lb/day (65.5 ton/day) NC produced

[3] 90,000 lb/day (45 ton/day) NC produced

[4] Does not include solvent recovery flow

TABLE 40
OVERALL DISCHARGES RESULTING FROM THE PRODUCTION OF NITROCELLULOSE

AAP	RAAP		BAAP	
Parameter	Discharge (lb/day)	Discharge (lb/ton of product*)	Discharge (lb/day)	Discharge (lb/ton of product**)
NO_2 + NO_3/N	4,700[1] (16,400)[2]	71.8 (250)	16,000[3]	356
TKN/N	4.65 (169)[2]	.070 (2.58)		
COD	9,460[1]	144	12,000[3]	267
BOD	29.0[1]	.442		
Total Solids	1,390[1] (247,000)[2]	21.2 (3,780)	240,000[3]	5,330
Suspended Solids	1,680[1] (4,330)[2]	25.6 (66.0)	18,200[3]	404
Dissolved Solids	1,180[1] (244,000)[2]	18.0 (3,730)	222,000[3]	4,930
Volatile Solids	195[1] (96,000)[2]	2.98 (1,460)		
Acidity	1.76[1]	.027		
Alkalinity	69.9[1]	1.07		
TOC	3,420[1]	52.2	3,050[3]	67.8
NH_3/N	50.5[2]	.771	14.4[3]	.32
PO_4/P	3.8[2]	.058	37.8[3]	.84
Fe			57.4[3]	1.28
SO_4			29,200[3]	649

*65.5 ton/day NC

**45.0 ton/day NC

[1] Reference (1.3)

[2] Reference (1.4)

[3] Reference (1.2)

34. SINGLE BASE PROPELLANTS

Single base propellants are manufactured at RAAP, InAAP, and BAAP (3e). However, while data concerning the wastes generated in the production of this solvent propellant was available only from RAAP, it may be considered typical. It should be noted that BAAP greenline nitrocellulose wastes (specifically, solvent recovery wastes) are discussed in Para. 33 of this report. Multibase propellants are discussed in Para. 35 and solventless propellants in Para. 36.

a. Process Description (RAAP)

For further details of process, the reader is referred to Chapter IV of this report.

The process steps are essentially the same in the production of the solvent-type single, double, and triple base propellants. Major differences are in the specific chemicals and explosive ingredients added. The production of all of the propellants begins with a dehy process which replaces water in the NC with alcohol and presses the NC into blocks. In the production of single base propellant, previously stored NC is sent to the Mixhouse where the blocks are charged into a mixer with solvents (alchol and ether) and various other chemical ingredients. The propellant is then sent to a Blocker House where it is screened and pressed into blocks. From the Blocker House, the propellant is taken to the Press and Cutting House where it is pressed and cut into strands and cut into specified lengths. The propellant is sent from here to the Solvent Recovery Area for further processing. In the production of multi-base propellants, other explosive materials are mixed with NC. In double and triple base propellant manufacturing, NG is combined with NC in the Premix Area No. 2 and then sent to the Propellant manufacturing areas for mixing with solvent and other chemicals, as in the Single Base Area. In the Mixhouse, nitroguanidine is combined with the NG-NC mixture, solvents, and other chemicals to form triple base propellants. High energy propellants require a separate blending process for the addition of ammonium perchlorate. Solvents used in the production of multi-base and high energy propellants include acetone and alcohol. Other chemicals vary depending upon the specific intended use of the propellant and are outlined in Table 41 (1n(3).

TABLE 41
CHEMICALS USED IN PROPELLANT MANUFACTURING (1n(3))

Propellant	Chemicals
Double Base	Barium Nitrate, Potassium Nitrate, Ethylcentralite, Graphite, Carbon Black
Triple Base	Ethylcentralite, Potassium Sulfate, Cryolite
High Energy	Resorcinol and HMX

6. Water Use and Wastewater Volume (RAAP)

(1) Water Use. Water use figures were not available, however, overall water use in the propellant area is estimated to be 2,740,000 gpd (1n(3).

(2) Distribution of Wastewater Volumes. Data allowing calculation of the overall volume of wastewater generated was not available. Tables I.N.1 through I.N.5, however, indicate discharge volumes of several of the major wastestreams.

Wastewaters generated in each solvent-type propellant manufacturing area are primarily the result of periodic (usually weekly) equipment and building washdowns. The wastewaters, after leaving the process buildings (in some cases passing through small screening devices and/or catch tanks), flow to the C-line Acid Neutralization Facility (from the Multi-Base Area) or directly to Stroubles Creek via an industrial sewer line (from the Single Base, A-line Area) (1n(3)).

Volumes of wastewater generated in this area were small compared to many other process operations within the plant and were almost entirely the result of water from shift and weekly equipment cleanup and floor washdown operations. Estimated volumes generated from the weekly washdown and cleanup operation in Buildings 1500, 1508, 1510, 1511, 1512, and 1513 amount to approximately 3700 gallons (ln(3)). The .038 mgd flow measured on the industrial waste sewer north of A-Line Single Base Propellant Area appears to be an adequate estimate of the total wastewater (including cooling water) generated in this line (see Table I.N.1, Appendix I).

c. Qualitative and Quantitative Aspects of the Pollutants Present in Liquid Wastes (RAAP)

What data is available is presented in Tables I.N.1 through I.N.5 (Appendix I).

Wastewaters resulting from washdown of individual bays in the Mixhouse contained very high concentrations of contaminants, most probably propellant. This was indicated by high concentrations of total solids, volatile solids, and extremely high COD. The five-day BOD of greater than 350 mg/l was due mainly to high concentrationsof ethyl alcohol, greater than 900 mg/l. Quantities of waste propellant were visibly present in all samples collected (see Table I.N.3, Appendix I) (ln(3)).

Significant quantities of diethyl and ethyl alcohol were found in wastewaters from the Blocker House and Press and Cutting House (see Tables I.N.4 and I.N.5, Appendix I) (ln(3)).

Wastewaters from the Mixhouse flow directly from drains under the building to a sewer line located northwest of the building, with no solids removal being accomplished by screens or catch basins. Screens and catch basins are located outside of other buildings in the area. No regular schedule of cleaning and maintenance of the screens and catch basins was being undertaken and accumulations of various waste materials was visually noted in several basins (ln(3)).

Dry sweeping prior to washdowns is done to reduce the amount of propellant washed out of the buildings. Study personnel were not able to ascertain fully the completeness and effectiveness of the operation. Performed with care, thorough sweeping would certainly reduce propellant loss during washdowns (ln(3)).

d. The Effects of Process Changes on Wastewater Characteristics (RAAP)

The following discussion applies to project activities at RAAP. A 20 percent sodium hydroxide solution heated to 217°F is used to clean metal objects, dies and screens which become contaminated with propellant during the shaping and extrusion opeations. After dipping in the caustic solution, the parts are rinsed with water. The caustic and the rinse tank are drained and the waste hauled by tank truck to the acid sewer. The planned Military Construction Army (MCA) project proposed neutralization of the waste with 73 percent sulfuric acid from the acid area. The neutralized solution is then to be hauled by tank truck to a waste propellant incinerator (design criteria being developed under Task 10 of the MM&T). Elimination of the waste from this operation will require further study. Consideration should be given to a method where both the caustic solution and the rinse water are recycled with the addition of sodium hydroxide and make-up water. Physical-chemical methods should be investigated which would make the recycling feasible. Propellant and sludge extracted could be treated in this area or transported to one of the other treatment facilities at the plant (ln(3)).

MCA 105A(b), "Wastewater Collection and Primary and Secondary Treatment System for Propellant Manufacturing Areas," calls for:

o Open drain guttering and primary solids separation facilities at individual process buildings to remove settleable solids;

o Sewer lines to secondary treatment;

- Separate storm systems for uncontaminated cooling water and storm runoff waters; and
- Secondary treatment facility with 3,000,000 gpd capacity.

This project will include both the solvent and rolled powder areas and should reduce both hydraulic and solids loadings (6a).

PE 210 will alleviate pollution from Solvent Recovery/Wash and Dry operations (6a). One solvent recovery building will be modified, five wash and dry buildings will be modified, and funding has been requested for the remaining buildings (1n(3)).

e. Data Limitations

Clearly, the data base necessary for making a detailed single-base wastewater characterization at RAAP or any of the other plants manufacturing this product does not exist.

Note that TRW (3f) reports discharges of 675,000 lb/day solids, 8,000 lb/day suspended solids, and 1,200 gal/day caustic solution for the single- and multi-base propellant areas. Examination of Tables I.N.1 through I.N.5 and I.O.1 through I.O.6 (Appendix I) reveals that only about 3 lb/day of total solids can be accounted for by the data presented here.

35. MULTIBASE PROPELLANTS

Multibase propellants are manufactured at RAAP and BAAP. Limited data characterizing some of the waste flows from the multibase production area at RAAP are incorporated in the present study.

a. Process Description (RAAP)

Refer to Para. 34.

b. Water Use and Wastewater Volume (RAAP)

(1) Water Use. Refer to Para 34.

(2) Distribution of Wastewater Volumes. Data allowing calculation of the overall volume of wastewater generated was not available. Tables I.0.1 through I.0.6 indicate discharge volumes of several of the major wastestreams. The sum of these flows is roughly 7,360 gpd.

As in the Single Base Propellant Area, wastewater flows generated in this area result primarily from cleaning of equipment and washdown of floors in production buildings (1n(3)).

c. Qualitative and Quantitative Aspects of the Liquid Wastes (RAAP)

Available data is presented in Tables I.0.1 through I.0.6 (Appendix I).

Washdown waters from the Multibase Mixhouse (see Tables I.0.1 and I.0.2, Appendix I) contained higher total volatile and dissolved solids leaving than found in floor wash waters from the Press and Cutting House (see Table I.0.4, Appendix I). Although only one sample was obtained frwm the High Energy Mixhouse washdown water during the USAEHA survey (1n(3)), solids concentration in the sample was in the same range as the measured solids values for the Mixhouses. It was felt that this indicated that propellant is being washed out of the buildings, and, where screening is inadequate, much of this is being lost to major plant outfalls.

High TOC concentrations (5000 mg/1; see Table I.0.6, Appendix I) in samples of wash water taken from the outside catch tank of the Slurry Mixhouse indicate that organic material (likely propellant) is being lost to the evaporation pond beside the building. The pond effluent showed a TOC concentration of 2000 mg/1 (ln(3)).

d. The Effects of Process Changes on Wastewater Characteristics (RAAP)

The reader is referred to Para. 34.

e. Data Limitations (RAAP)

The discussion presented in Para. 34 is also applicable here.

36. SOLVENTLESS PROPELLANTS

There are several plants engaged in the manufacture of solventless propellants. It appears, however, that the final products at each plant are too different in terms of structure, production rate, and manufacturing processes to allow cross-correlation analysis.

Data on solventless propellant operations exists only from RAAP and BAAP.

a. Rolled Powder (RAAP)

(1) Process Description. Production of solventless propellants, referred to as rolled powder, involves similar process steps, but without the addition of solvents in the mixing step. Propellant, after the addition of NG, air drying and temporary storage, is processed through a blender. From the blender, the "powder" is transported to the Preroll Building and then to the Final Roll Process. The sheets produced from the rolling operations are cut and made into "carpet rolls" or otherwise shaped as desired. These products then proceed for final processing and preparation for shipment. Again the primary source of wastewaters are from building and equipment washdown. During washdowns in the Preroll Building, wastewater flows from concrete gutters within the buildings into catch tanks outside the buildings and then into a general purpose sewer line. After passing through a larger settling tank the effluent is discharged to the New River. Certain cleaning mixtures are used in conjunction with the washdown of equipment in this area. These include a mixture of 58 percent soda ash and Johns-Manville No. 450 Insulating Cement (asbestos) used to clean chemical salts from the differential rolls in the Preroll Building. Rolls are subsequently cleaned using a solution of Oakite 20, Colgate Arctic Syntex M-Beads with water. Now and then, accidental ignition of propellant

while on the prerolls in Building 9309-4 activates an automatic sprinkling system which drowns the fire; but in the process, quantities of propellant are washed out of the building and into the wash water gutters. From the blending operation, wastewaters are produced from floor and equipment washdown during and after operation, plus from a rotoclone used to pick up dust in the air during the blending operation. Wastewaters flow to a catch tank, to a larger settling tank and then to an open ditch (1n(3)).

(2) Water Use. Water usage figures were not available. Process water use will be roughly equivalent to the measured wastewater volume.

(3) Distribution of Wastewater Volumes. Tables I.P.1 through I.P.5 indicate some of the major wastewater flows. Total wastestream flow indicated by these tables is 89,600 gpd. This is primarily washdown water. TRW (3f) indicates a wastewater volume of 3,000,000 gpd for this area.

(4) Qualitative and Quantitative Aspects of the Liquid Wastes. Examination of Tables I.P.1 through I.P.5 indicates the absence of excessively large discharge loads except possibly for the total solids (largely dissolved) content (approximately 200 lb/day). TRW indicates (3f) discharges of 5000 lb/day total solids, 5000 lb/day BOD, and 12000 lb/day COD. In view of the large disparity between USAEHA data (1n(3)) and TRW data (3f) it would seem likely that data from either or both of the reports is inadequate or inaccurate.

(5) Effects of Process Change on the Wastewaters. Since a detailed wastewater characterization has not been effected, it is impossible to predict what effects process changes will have on the wastestreams in their entirety. The discussion presented in Para. 34 is applicable here since MCA 105A(b) includes the Rolled Powder Area.

(6) Data Limitations. Again it may be stated that the data base for a detailed wastewater characterization simply does not exist.

b. Ball Powder (BAAP)

BAAP is the only AAP in the U.S. Army Armament Command Complex that manufactures ball powder. Current production rate is 900,000 lb/month (30,000 lb/day). Mobilization-rate production is projected to be 2.7 million pound/month (90,000 lb/day) (3a).

(1) Process Description and Water Usage. The entire ball powder operation prior to reaching the drier is accomplished with the propellant in a water slurry. A flow chart of the manufacturing process is shown in Figure 6. A house-by-house breakdown of water usage up to the drier can be seen in Table 42.

In the ball powder operation, 100 percent of the cooling water is recycled. Fifty percent of the wastewater consumed is in the wet screen operation (3a).

(2) Qualitative and Quantitative Aspects of the Liquid Wastes. Table I.P.6 (Appendix I) presents the detailed results of USAEHA measurements made in 1970 (1a(2)). It must be assumed that cooling water wastes were not included in these measurements and that the concentrations listed correspond only to process waters. Benzene, ethyl acetate, NC, NG, sodium sulfate, and protein colloids have also been indicated to be contaminants of the wastewater discharged from ball powder operations.

The use of protein colloids (animal glue from Swift & Co.) in the manufacture of ball powder increases the BOD and causes a foam problem which manifests itself in the plant effluent at the exit of the 25-acre sedimentation pond. The colloid is used to keep particles separate during ball powder manufacturing (to avoid conglomeration). It collects on the bottom of ponds and also produces surface foam (3f).

(3) Effects of Process Change on the Wastewaters. Steps have been undertaken to allow recycle of the water at the Wet Screen House (3a). since this house uses 50 percent of the water in the ball powder area.

Due to the widespread nature of the ball powder manufacturing operation, additional recycling would not be feasible on an economic basis only. However, in the single base extraction and ball powder hardening operations, a closed-water system would be environmentally advantageous since benzene is used in the former and sodium sulfate and colloid are used in the latter. Engineering changes are being implemented to prevent large quantities of benzene from entering the sewer. A project has been initiated to evaluate the use of a trickle filter for processing the colloid waste from the hardening operation (3a).

If it is assumed that the wet screen operation can be made a self-contained, closed-loop system, the total effluent at full production would be approximately 76.87 million gallons per month. Of this, approximately 20.99 million gallons would be contamined with benzene, ethyl acetate, nitrocellulose, nitroglycerine, and sodium sulfate (3a).

Further investigation into the types of contamination, suitable means of processing, and the economic impact of processing and recycling in the existing facilities is required (3a).

A complete listing of water usage at the current production rates and the projected water usage at full mobilization production rate are given in Table 43.

(4) Data Limitations. Insufficient data exists on either the distribution of wastewater volumes or the nature of the waste streams. A complete and detailed characterization of the wastewaters generated in ball powder operations at BAAP is not possible with the given data base.

c. Rocket Area (BAAP)

(1) Process Description and Water Usage. Rocket manufacturing is basically a solventless operation. An initial water slurry is made at the premix house and transferred to the final mix process where it is centrifuged. Almost all the process water remains in a closed system. After the slurry is centrifuged, no water is added to the mixing mixture throughout the remainder of the operation. The remaining process water is consumed at House 6731 and House 6814. A flow chart of the rocket manufacturing process is shown in Figure 7 (3a).

Current production rate of rocket propellant is 280,000 lb/month (9330 lb/day). At mobilization for the existing facilities this production rate would increase to 2.7 million lb/month (90,000 lb/day).

Water usage by manufacturing operations are shown in Table 44. It can be seen that the Dowel and Spiral Wrap chip collector uses only 3.8 percent of the 16,000,000 gallons total; therefore, recycling would be impractical for economic reasons only. This is an important point since the only process water which is not being recycled is from the Dowel and Spiral Wrap operations and wash down in the Roll and Press Area. This wastewater accounts for 6.5 percent of the water entering the sewage system from the Rocket Area. Due to the small quantity (988,520 gal/month) and low cost ($54.37/month) of this amount of water, recycling these streams would not be practical from an economic standpoint in the present operation (3a).

The major areas of concern are those where large volumes of water are used for cooling water. Due to procedural changes that have resulted, the pre-mix and final mix houses in the Paste Area have cut water consumption by 50 percent. This was accomplished by reducing the flow through heat exchangers in operation and by closing and draining the lines which were running to prevent freeze up. Water usage by area, after the procedural change, is shown in Table 45. Cooling water usage in the Roll and Press Area was found to be optimized and will remain unchanged (3a).

Projections were made of water usage in the Rocket Area at increased production rates. Table 45 shows the projected water usage by manufacturing operations. In arriving at the projected water usage rates, it was assumed that the reduced flow rate through heat exchangers which resulted from procedure changes would apply at the increased production rates. The figures given were obtained by determining a gallon per pound ratio based on present production and expanding to the increased production capabilities (3a).

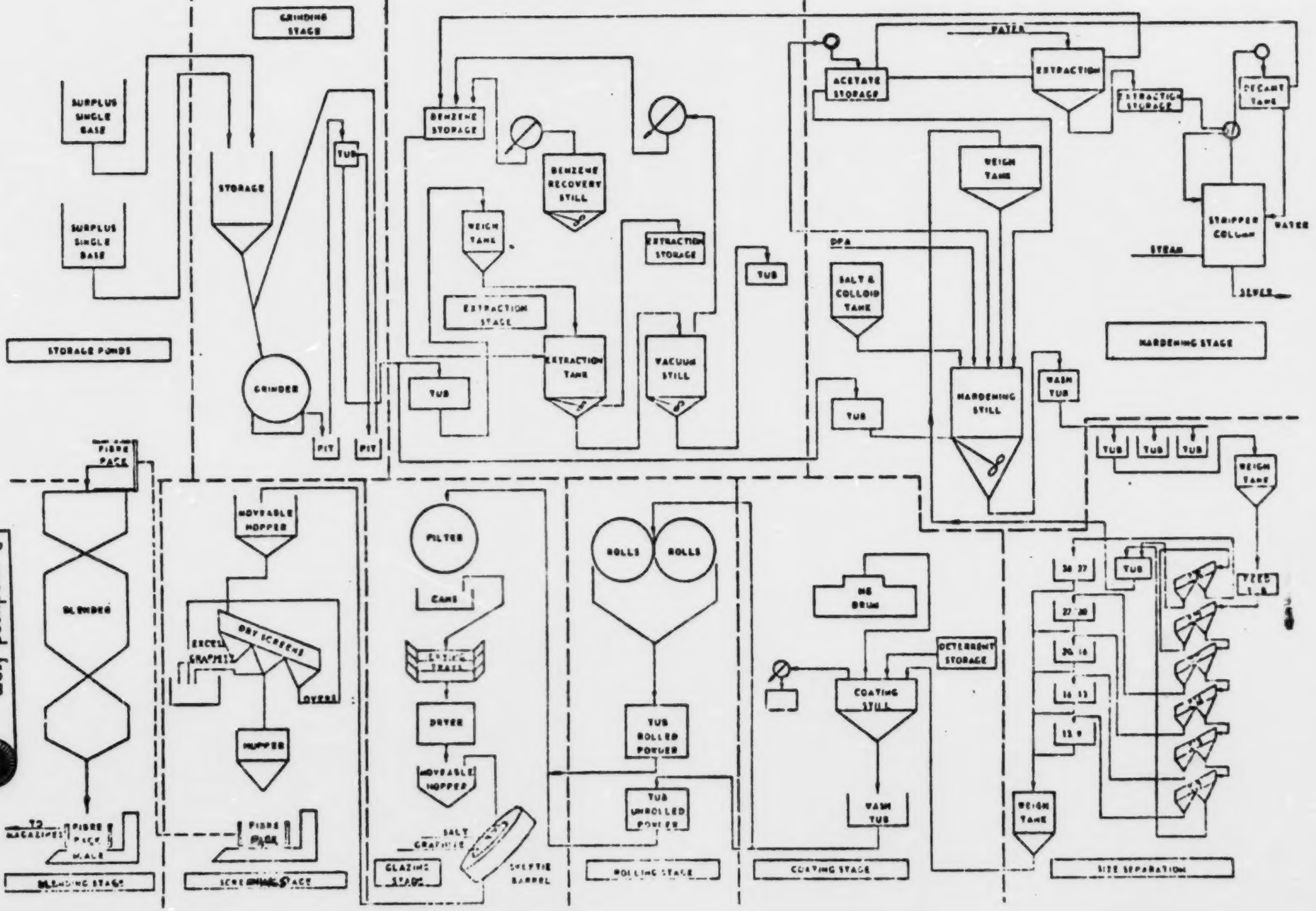
(2) Qualitative and Quantitative Aspects of the Liquid Wastes. No analytical data for the wastewater streams from this area was available. Heat can be expected to be of primary consideration as a potential pollutant.

At maximum production rates (mobilization), process water consumption is expected to be roughly 9.8 million gallons per month. This water would be slightly contaminated with NC fines, NG (dissolved), and small quantities of other chemicals used in the production of various formulations of rocket propellant (3a).

(3) Effects of Process Changes on the Wastewaters. No further modernization or pollution abatement programs that would directly affect the nature of the wastewaters generated in the Rocket Area are planned.

(4) Data Limitations. Presently existing chemical and physical data is inadequate for characterization of the liquid wastes from this area.

FIGURE 6
FLOW CHART BALL POWDER (3a)



GRINDING STAGE
SURPLUS SINGLE BASE
SURPLUS SINGLE BASE
STORAGE
TUB
GRINDER
PIT
PIT
STORAGE PONDS
BENZENE STORAGE
BENZENE RECOVERY STILL
WEIGH TANK
EXTRACTION STAGE
EXTRACTION TANK
EXTRACTION STORAGE
VACUUM STILL
TUB
TUB
ACETATE STORAGE
WATER
EXTRACTION
EXTRACTION STORAGE
DECANT TANK
STRIPPER COLUMN
WATER
STEAM
SEWER
DPA
SALT & COLLOID TANK
WEIGH TANK
HARDENING STILL
TUB
WASH TUB
HARDENING STAGE
TUB
TUB
TUB
WEIGH TANK
FIBRE PACK
BLENDER
TO MAGAZINES
FIBRE PACK
MALE
BLENDING STAGE
MOVABLE HOPPER
DRY SCREENS
EXCESS GRAPHITE
OVERS
HOPPER
FIBRE PACK
SCREENING STAGE
FILTER
CANS
DRYING TRAYS
DRYER
MOVABLE HOPPER
SALT
GRAPHITE
SWEETIE BARREL
GLAZING STAGE
ROLLS
ROLLS
TUB ROLLED POWDER
TUB UNROLLED POWDER
ROLLING STAGE
NG DRUM
DETERGENT STORAGE
COATING STILL
WASH TUB
COATING STAGE
36 37
27 28
26 16
16 13
13 9
TUB
FEED
WEIGH TANK
SIZE SEPARATION

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TABLE 42
BALL POWDER WET LINE WATER USAGE
AT CURRENT PRODUCTION RATES OF 900,000 POUNDS/MONTH (3a)

House	Use	Gallons/Month
9590 Storage Pits	debagger spray	201,600
	debagger flush water	685,440
21 day month	storage pit replenish water	1,251,936
HOUSE TOTAL		2,138,976
Percentage of Grand Total		3.1%
9591 Grinding	sump pump flush water	220,800
	ground powder tub flush water	110,400
30 day month	receiving tub flush water	55,200
	grinding mill flush water	504,528
	receiving hopper	750,720
	sewer flush	662,400
	pyc tank	2,630,200
HOUSE TOTAL		4,934,248
Percentage of Grand Total		7.1%
9592 Extraction	from stripper still to sewer (highly contaminated)	375,360
30 day month	from recovery still to sewer (highly contaminated)	1,218,816
	sewer flush	1,324,800
	vacuum pump seal	662,400
	transfer water	1,523,520
HOUSE TOTAL		5,104,896
Percentage of Grand Total		7.3%

TABLE 42
(continued)

House	Use	Gallons/Month
9500-3 Hardening Weigh	pyc tank	1,402,758
	water required to fill line	873,600
21 day month		
HOUSE TOTAL		2,276,358
Percentage of Grand Total		3.3%
9501-3 Hardening House	initial water layer in still	379,300
21 day month	wash water (contaminated with colloid and salt)	11,684,736
	pump seal water	988,217
	make up water	834,624
HOUSE TOTAL		13,986,877
Percentage of Grand Total		20.0%
9501-2 Hardening House for Solvent Stripping	initial tank fill	65,730
	wash water	676,330
21 day month		
HOUSE TOTAL		742,060
Percentage of Grand Total		1.1%
9503 Wet Screen	slurry water	36,288,000
21 day month		
HOUSE TOTAL		36,288,000
Percentage of Grand Total		51.9%

TABLE 42
(continued)

House	Use	Gallons/Month
9522 Cooling Tower	water added to system	1,468,800
30 day month		
HOUSE TOTAL		1,468,800
Percentage of Grand Total		2.1%
9505 Single Base Clarifier	make up water	596,160
30 day month		
HOUSE TOTAL		596,160
Percentage of Grand Total		0.9%
9507 N.G. Transfer House	N.G. transfer	302,400
21 day month		
HOUSE TOTAL		302,400
Percentage of Grand Total		0.4%
9506-1 Coating	transfer flush water	241,920
	wash tub	1,163,770
21 day month	decant water	155,230
	vacuum pump seal	272,160
HOUSE TOTAL		1,833,080
Percentage of Grand Total		2.6%

TABLE 42
(continued)

House	Use	Gallons/Month
9509-1 Roll and Dewater	roll spray	85,680
	pump flush to dewater operation	18,900
21 day month	spray for receiving hopper	86,400
HOUSE TOTAL		190,980
Percentage of Grand Total		0.3%
BALL POWDER AREA GRAND TOTAL:		69,862,835

TABLE 43
BALL POWDER WET LINE PROJECTED WATER USAGE AT PRODUCTION RATES OF 2,800,000 POUNDS/MONTH AFTER PROCEDURAL CHANGES (3a)

House	Use	Gallons/Month
9590 Storage Pits	debagger spray	201,600
21 day month	debagger flush water	685,440
	storage pit replenish water	1,251,936
HOUSE TOTAL		2,138,976
Percentage of Grand Total		2.7%
9591 Grinding	sump pump flush water	220,800
30 day month	ground powder tub flush water	110,400
	receiving tub flush water	55,200
	grinding mill flush water	504,528
	receiving hopper	750,720
	sewer flush	662,400
	pyc tank	2,630,200
HOUSE TOTAL		4,934,248
Percentage of Grand Total		6.3%
9592 Extraction	from stripper still to sewer (highly contaminated)	375,360
30 day month	from recovery still to sewer (highly contaminated)	1,218,816
	sewer flush	1,324,800
	vacuum pump seal	662,400
	transfer water	1,523,520
HOUSE TOTAL		5,104,896
Percentage of Grand Total		6.5%

TABLE 43
(continued)

House	Use	Gallons/Month
9500 - 2 & 3 Hardening Weigh	pyc tank	4,364,136
	water required to fill line	2,717,867
30 day month		
HOUSE TOTAL		7,082,003
Percentage of Grand Total		9.0%
9501 - 2 & 3 Hardening House	initial water layer in still	1,180,044
30 day month	wash water (contaminated with colloid and salt)	36,352,512
	pump seal water	3,074,453
	make up water	2,596,608
HOUSE TOTAL		43,203,617
Percentage of Grand Total		55.1%
9501-1 Hardening House used for Solvent Stripping	initial tank fill	204,493
	wash water	2,104,138
21 day month		
HOUSE TOTAL		2,308,631
Percentage of Grand Total		2.9%
9503 Wet Screen	slurry water - recycled	0
30 day month		
Percentage of Grand Total		0

TABLE 43
(continued)

House	Use	Gallons/Month
9522 Cooling Tower	water added to system	4,569,600
30 day month		
HOUSE TOTAL		4,569,600
Percentage of Grand Total		5.8%
9505 Single Base Clarifier	make up water	1,854,720
30 day month		
HOUSE TOTAL		1,854,720
Percentage of Grand Total		2.4%
9507 N.G. Transfer House	N.G. transfer	940,800
30 day month		
HOUSE TOTAL		940,800
Percentage of Grand Total		1.2%
9506-1 Coating	transfer flush water	752,640
30 day month	wash tub	3,620,618
	decant water	482,938
	vacuum pump seal	846,720
HOUSE TOTAL		5,702,916
Percentage of Grand Total		7.3%

TABLE 43
(continued)

House	Use	Gallons/Month
9509-1 Roll and Dewater 30 day month	roll spray	266,560
	pump flush to dewater operation	58,800
	spray for receiving hopper	268,800
HOUSE TOTAL		594,160
Percentage of Grand Total		0.8%
BALL POWDER AREA GRAND TOTAL:		78,434,568

FIGURE 7
FLOW CHART-MARK 43 & N5 (3a)

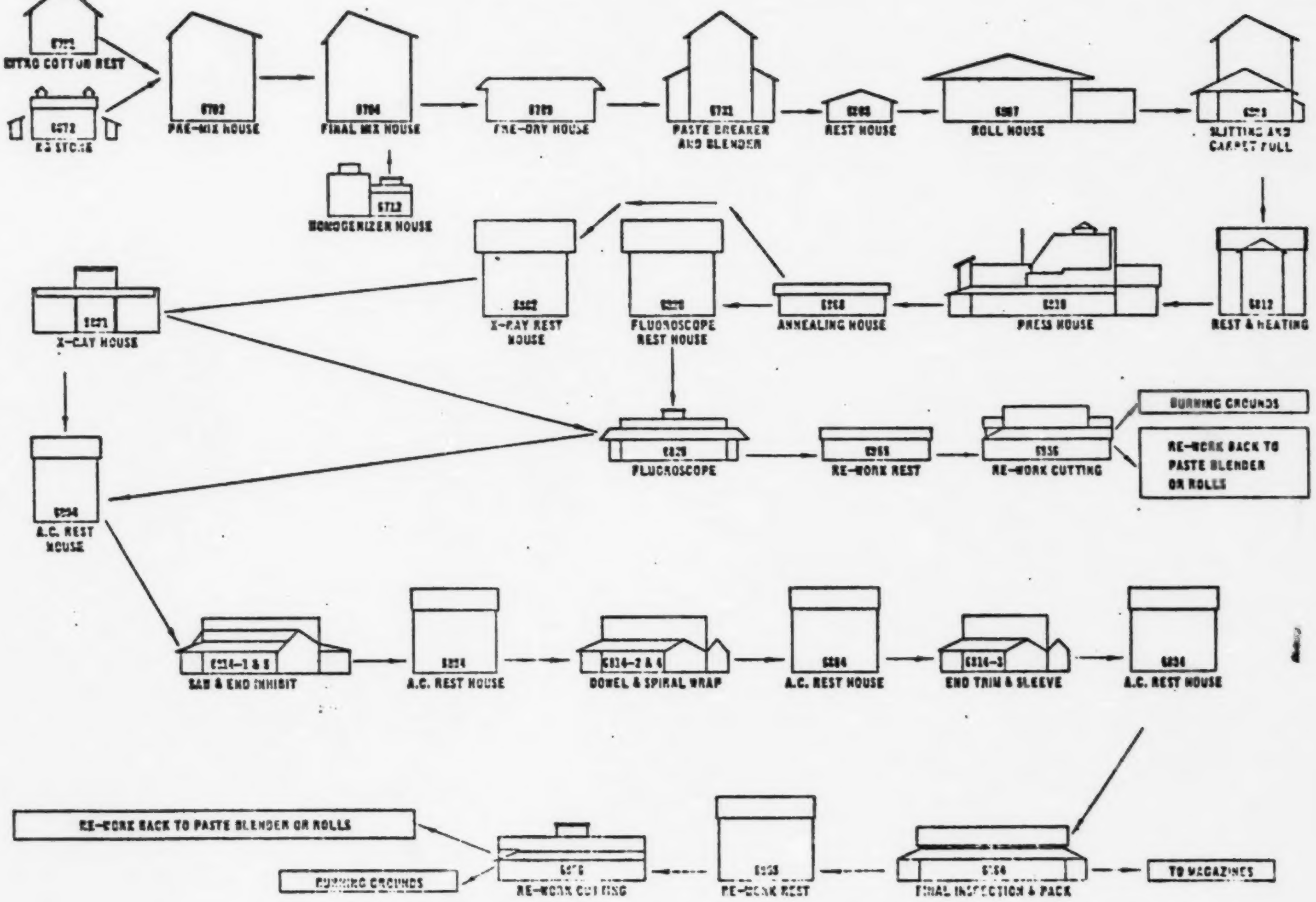
NITRO COTTON REST
RX STORE
6702
PRE-MIX HOUSE
6704
FINAL MIX HOUSE
6712
HOMOGENIZER HOUSE
PRE-DRY HOUSE
PASTE BREAKER AND BLENDER
REST HOUSE
ROLL HOUSE
SLITTING AND CARPET FULL
6812
REST & HEATING
PRESS HOUSE
ANNEALING HOUSE
FLUOROSCOPE REST HOUSE
X-RAY REST HOUSE
X-RAY HOUSE
A.C. REST HOUSE
FLUOROSCOPE
RE-WORK REST
RE-WORK CUTTING
BURNING GROUNDS
RE-WORK BACK TO PASTE BLENDER OR ROLLS
SAW & END INHIBIT
A.C. REST HOUSE
6814-2 & 4
DOWEL & SPIRAL WRAP
A.C. REST HOUSE
6814-3
END TRIM & SLEEVE
A.C. REST HOUSE
FINAL INSPECTION & PACK
TO MAGAZINES
RE-WORK REST
RE-WORK CUTTING
RE-WORK BACK TO PASTE BLENDER OR ROLLS
BURNING GROUNDS

TABLE 44
ROCKET AREA WATER USAGE DETERMINED AT CURRENT PRODUCTION RATES (3a)

Area	Gallons/Month Recycled	Gallons/Month to Waste Water Streams	Total Gallons/Month
Paste:			
Process	333,200	25,700 (Tank Wash) 216,720 (Wet Floor)	
Cooling	0	10,696,700	
Area Total			11,272,320
Percentage of Grand Total	2.1%	68.5%	70.6%
Roll & Press:			
Process	0	167,000 (Washdown)	
Cooling	0	604,800 (Vacuum) 3,316,320 (Hydraulic)	
Area Total			4,088,120
Percentage of Grand Total	0	25.6%	25.6%
Finishing:			
Process	0	604,800 (D & SW)*	
Cooling	0	0	
Area Total			604,800
Percentage of Grand Total	0	3.8%	3.8%
		GRAND TOTAL	15,965,240

* Dowell and Spiral Wrap

TABLE 45
ROCKET AREA WATER USAGE AFTER PROCEDURAL CHANGES AT PRESENT PRODUCTION RATE OF 0.28 MILLION POUNDS/MONTH (3a)

Area	Use of Water	Gallons/Month
Paste	tank wash	25,700
	wet floors	216,720
	cooling hydraulic system	3,696,700
TOTAL		3,939,120
Roll & Press	wash down	167,000
	cooling vacuum system	604,800
	cooling hydraulic system	3,316,320
TOTAL		4,088,120
Finishing	dowell and spiral wrap flush	604,800
TOTAL		604,800
TOTAL AREA USAGE		8,632,040

TABLE 46
ROCKET AREA PROJECTED WATER USAGE AFTER PROCEDURAL CHANGES AT PRODUCTION RATE OF 2.7 MILLION POUNDS/MONTH (3a)

Area	Use of Water	Gallons/Month
Paste	tank wash	247,821
	wet floor	2,089,800
	cooling hydraulic system	35,646,750
TOTAL		37,984,371
Roll & Press	washdown	1,610,357
	cooling vacuum system	5,832,000
	cooling hydraulic system	31,978,800
TOTAL		39,421,157
Finishing	dowell and spiral wrap flush	5,832,000
TOTAL		5,832,000
TOTAL AREA USAGE		83,237,520

37. LOAD, ASSEMBLE, AND PACK (LAP) OPERATIONS

Information as to the nature, source, and quantity of wastewaters generated in LAP operations is not complete. Information on surface water pollutant loading situations from LAP's is also somewhat sketchy because of the general practice of disposing of TNT wastewaters in evaporation ponds. In these situations, the mode of TNT introduction into surface streams could be either by pond washout during heavy rains or by groundwater infiltration. There have been no TNT analyses performed at wells with drawdowns below the levels of LAP evaporation ponds which would indicate infiltration (2b). What LAP wastewater data is available is discussed below on a plant-by-plant basis.

a. Aspects of LAP Wastewaters

(1) Cornhusker Army Ammunition Plant (CAAP) (Note: Currently inactive). Industrial wastewaters generated on the installation are attributable primarily to the load lines. Each of these lines is similar in configuration and in quantity of wastewater discharged. Also, liquid wastes from each line are primarily washdown waters. Average daily waste volume per line is approximately 6,300 gallons. Other sources (cited in Reference (2b)) estimate waste flows from active LAP lines at between 9,600 and 28,800 gpd per line. These waters are disposed of by percolation and evaporation in a network of tanks and basins located throughout the load line area. It has been suggested that these wastes instead be directed to adequately sized evaporation ponds located appropriately within the loading area 1c(1).

Table 47 presents a breakdown of the industrial wastewater volumes generated on a typical load line at CAAP. The primary mission of this plant is the loading of heavy munitions. Operations consist of the loading of eight-inch shells, as well as 500-, 750-, and 1,000-pound bombs. The eight-inch shells are loaded with pure TNT, while the bombs are loaded with tritonal, a composition consisting of 80 percent TNT and 20 percent flaked aluminum (1c(1)).

As discussed, wastewater from these operations is routed through settling ponds which are periodically cleaned of solids. The discharge from these ponds averages 57 mg/l TNT content (16f). Assuming a compromise flow rate of about 10,000 gpd from each line, a 9.5 pound per day TNT loading (discharge) is estimated. These wastewaters are discharged to pits with no apparent outfalls. Laundry wastes, estimated at 15 gallons per minute, contain about 2.7 mg/l TNT (3r). Assuming 16-hour flow, this amounts to an additional 0.3 pounds per day TNT discharge. This waste flows into intermittent streams which normally dry up and have no surface outfall (3r). Overall TNT discharge may therefore be estimated at 9.8 lb/day. Entrance of this discharge into more or less consistent water flows must be by groundwater infiltration.

(2) Iowa Army Ammunition Plant (IAAP). IAAP loads a variety of explosives into shells and is currently operating at about 40 percent capacity. Wastewaters from these activities are estimated at 90,000 gpd (3s). These wastewaters are subjected to diatomaceous earth filtration followed by adsorption on granular carbon in packed columns.

Of the 90,000 gpd discharged at IAAP, roughly 25,000 gpd is pink water generated from LAP activities (2b). Some TNT (perhaps 10 mg/l) appears in laundry wastewaters, estimated at 8,000 gpd, which are being discharged into surface streams (15u). Assuming that carbon column discharges contain 1 mg/l TNT and laundry flows are as previously cited, TNT loadings would be about one pound per day (15u).

If the RDX content of IAAP wastewaters is similar to those of JAAP (145 ppm raw and 20 ppm final carbon column), then the discharge of RDX to the diatomaceous earth filters is approximately 109 lb/day RDX. Under the same considerations, roughly 15 lb/day RDX may be discharged to surface streams from the granular carbon packed columns. IAAP has measured RDX in spot tests of Brush Creek, a stream which originates on the installation and carries the bulk of explosive wastewater. RDX concentrations of 0.1 to 0.15 mg/l have been measured, but no corresponding flow data was taken (3s).

At IAAP, booster charges are molded from bulk explosives. In 1973, about 11,000 lb/day of tetryl were so processed. Only small amounts of tetryl-containing wastewater, estimated at 1,500 gallons per week (215 gpd), are generated (3s). This wastewater is transported to a sedimentation pond for which no estimate of tetryl content is available (2c).

(3) Indiana Army Ammunition Plant (InAAP). LAP operations consist of fabricating cloth bags and loading mortar and cannon propellant into these bags. The bags are manufactured from purchased cloth and made to various sizes. Paper tubes are also manufactured for the packaging of propellant bags before inserting them into a box for shipment. Titanium dioxide is purchased and blended with a wax compound for gun tube protection (1f(1)).

Cooling towers are used in the loading plant to condition air. A closed-loop system is used with a minimum of blowdown. Copper piping is used in the system, and no corrosion inhibitors or fungicides are required (1f(1)).

No appreciable amount of industrial wastewater is generated from these LAP operations (1f(1)).

(4) Joliet Army Ammunition Plant (JAAP). LAP operations at JAAP include loading of medium caliber ammunition and ammunition components (except small arms) in Group 3 and Group 4 Areas. At the time of the 1973 USAEHA report (1g(3)) the LAP Area operated on a two shift/day, five-day work week. Roughly .015 mgd of TNT-containing washwater is reported to be generated in Group 4 Area each day, all of which receives treatment (1g(3)).

The 1974 USAMBRDL report (2c) indicates that JAAP currently has only one LAP line in operation where Composition B is being loaded into 105 mm shells at a rate of 200,000 shells per month. Explosives wastewaters amount to 6,200 gpd (note that this is less than one half the figure cited above). These wastewaters are collected in a catch basin, filtered through diatomaceous earth and then through two granulated charcoal columns prior to discharge into surface drainage (2c) A recent USAEHA survey (1g(3)) of JAAP included extensive testing of these wastewaters. RDX content was reduced from a mean value of 145 ppm in catch basin water to 20 ppm in final carbon column effluent. At a flow of 6,200 gpd this corresponds to a raw waste discharge of 7.5 lb/day RDX and a treated waste discharge of approximately one lb/day RDX.

(5) Kansas Army Ammunition Plant (KAAP). Explosives, primarily formulations of TNT and RDX, are loaded into ordnance items in melt-pour buildings in Areas 900 (81 mm load line), 1,000 (105 mm load line), and 1,100 (CBU line). Steam is used to melt the explosive and for cleaning forms, trays, and other equipment used in melt-pour operations. Explosives-bearing watewaters flow or are trucked to evaporative ponds. The residual sludge from these ponds is either burned or buried. There is no available data to indicate the extent of RDX intrusion into groundwaters as a result of ponding procedures. Occasionally, through leaks in pond walls or over-

flow in heavy rain, some explosives are introduced into surface streams (2c). Eventually the treatment system at each of these areas will consist of sumps follows by anthracite filters. A portion of the waste will then be recirculated and the remainder treated by diatomaceous earth filter followed by a carbon column. This type of recirculation system is currently being developed in each of these areas (1h(3)).

Detonators for 105 mm howitzer shells are also manufactured at KAAP. The detonators are loaded with lead azide, lead styphnate, and RDX. The detonator mixture is blended in this area, and the associated wastes from floor wash downs and from a scrubber system are collected in sumps. These wastes are batch treated in a series of reactions to deactivate the explosives present. Sodium nitrite and acetic acid are used to deactivate the lead azide. Caustic soda (NaOH) is added to the holding tank at a later time to assure the killing of lead styphnate. Caustic soda is also used to deactivate the RDX. In addition, caustic soda is spread on areas adjoining the sumps and holding vats to eliminate explosives contamination. In the front line, where the explosive mixture is loaded into the primer cup, explosive dust is drawn from the machine area and passed through glass jugs filled with water. These solutions are also "killed" prior to disposal. After deactivation, water from the sumps drains into ditches and flows to holding ponds. Sludges from the sumps are collected periodically and taken to the burning ground for disposal. The approximate daily flow is 2,500 gallons (1h(3)).

(6) Lone Star Army Ammunition Plant (LSAAP). Explosive-contaminated pink water generated in Area O (Melt-Pour Line; intermittent flow) is discharged directly to the Red Water Lakes. This lagoon system acts as a means of wastewater reduction. Composition-B is the primary raw material

used in Area O, and the wastes discharged from this area include raw sewage and storm-water runoff and may contain NO_3, TOC, color, TNT, and extreme pH (not specified). Pink water generated at Areas C (Melt-Pour; intermittent flow), E (Melt-Pour; intermittent flow), and G (Melt-Pour; continuous flow) is passed through a bed of granular anthracite coal to remove suspended material and reused on a batch basis (lk(2), (15v)). Composition-B is the primary raw material in Area C, and the wastewaters from this Area include raw sewage and storm-water runoff and may contain NO_3, TOC, color, TNT, and extreme pH (not specified). TNT and Composition-B are the raw materials used in Area E. Wastes from this Area include storm-water runoff and raw sewage and may contain NO_3, TOC, color, TNT, and extreme pH (not specified). Wastewater sources and character for Area G are similar to those from Area E except that octyl is used as one of the raw materials (lk(2)).

An estimated 20,000 gpd of pink water is generated in Areas C, E, and G. When TNT concentrations in this wastewater become excessive (about 50 mg/l), this water is removed from recycle and trucked to holding ponds. Occasionally these ponds flood due to heavy rains, and diluted contents will flow to an intermittent-stream (lk(1)). It should be noted that this pink water flow is also likely to contain RDX and octol.

Lead azide, an initiating explosive, is loaded at Areas P (Load Line; intermittent flow) and Q (Load Line; continuous flow) using a basically dry operation. Wastewaters generated in this area include treated industrial sewage, raw sewage, and storm-water runoff, and are reported to contain no pollutants (lk(2)). Due to the sensitive nature of lead azide, any waste material must be desensitized. Wasted lead azide is slurried in stainless steel vats and batch destruction of the compound is achieved by the addition of cerric ammonium nitrate. The supernatant from the vats is discharged to an evaporation pond where lead is precipitated as an oxide. Following heavy rainfall, overflow from the ponds in Areas P and Q may reach surface waters (1k(2)).

Black powder is loaded in a dry process in Area R (Dry Load; intermittent flow). The only liquid wastes from this area are raw sewage and stormwater runoff which are reported to contain no pollutants. No process (industrial) wastewater is generated. Spilled black powder is cleaned up by a dry method and presently disposed of by dumping into natural surface waters. The black powder used has the composition: 75 percent potassium nitrate, 15 percent charcoal, and 10 percent sulfur. Roughly 50 pounds of black powder are dumped per week. An MCA project, FY 78, will provide an incinerator for proper destruction of this waste (1k(2)).

(7) Longhorn Army Ammunition Plant (LHAAP). In the M120 Area at LHAAP, the mixing, processing, and loading of propellants for rocket motors are conducted. The other areas are primarily assembly areas and generate little waste. Liquid wastes from all areas flow through sumps and into surface water. Waste propellants settled out in the sumps are pumped periodically into trucks and hauled to the evaporation pond at the explosive burning grounds. These solids consist primarily of polysulfide polymers, aluminum powder, ammonium perchlorate, and black powder. The ammonium perchlorate used as an oxidizer in the rocket propellant is water soluble. Ammonium perchlorate transport containers are washed at Building 17-D. The waste-containing wash water is stored in a 35,000 gallon storage tank and is released to surface drainage at such a time when the flow is enough to give adequate dilution (1j(2)).

No MCA or modernization effort related to water pollution abatement is known to be scheduled. Although BOD, COD, manganese, cyanide, nitrate, phosphate, iron, and cadmium may exceed APSA boundary guidelines, biological indicators of water quality indicate that no waste materials of significant toxicity to aquatic life are being discharged by LHAAP (1j(2)).

(8) Louisiana Army Ammunition Plant (LAAP). Full capacity shell-loading operations at LAAP generate approximately 138,000 gpd wastewater with a TNT content of about 80 mg/1. This water is trucked to leaching ponds on the plant grounds (2b). Some TNT was noted in surface runoff, probably due to spills (1ℓ(1)), but groundwater intrusion from the leaching ponds cannot be ruled out. At times of heavy rainfall, these ponds fill to overflowing. Leaks created by gophers have been known to cause the loss of some water from these ponds (2b).

Using the above figures it appears that roughly 9.2 pounds of TNT are trucked to leaching ponds each day. RDX can also be expected to be present in these wastes.

(9) Milan Army Ammunition Plant (MAAP). The USAMEERU Phase I report (2b) indicated about a .75 mgd wastewater discharge from LAP operations at MAAP. In-plant surveys of the wastewater indicate that TNT concentrations are usually less than 1 mg/1. One of the LAP lines is used for washout of rejected shells, and wastewater from this line discharges to an unlined leaching pit (15w). This flow is estimated at less than 50,000 gpd. Its concentration is about 40 mg/1 TNT. Milan AAP wastewaters are discharged into a drainage canal which flows to surface water.

A later USAMBRDL report (Phase II; (2c)) indicated .4 mgd overall MAAP wastewater discharges, and not all of these were generated from LAP processes. Assays of wastewater samples from the effluent ditches indicated from 0 to 1.1 mg/1 RDX (h.18). Presuming 0.5 mg/1 mean RDX concentration, perhaps 2 lb/day RDX is released to surface waters (2c). Using a flow figure of 50,000 gallons per 90 days for the effluent from the shell washout facility and presuming this flow to be as concentrated with RDX as water from the JAAP catch basin (145 ppm), about 60 lb/3 month (.7 lb/day) RDX is discharged from this operation.

Using data from the later USAMBRDL report (2c) and assuming:

- One ppm TNT in all but the shell washout wastewater -- where overall discharge is .4 mgd and shell-washout discharge is 555 gpd;
- 40 ppm TNT in the shell-washout water;
- 2 + .7 = 2.7 lb/day RDX discharge;

then the overall TNT discharge from MAAP is roughly 3.5 lb/day and the overall RDX discharge is roughly 2.7 lb/day.

(10) Ravenna Army Ammunition Plant (RaAAP). RaAAP no longer engages in LAP operations, and historical data were not available.

(11) NAD Crane (15ze). Located in Indiana, NAD Crane is a Navy LAP plant for explosives only. No propellants are loaded here. Explosives are loaded by melt-cast and press-load processes. As is the case at typical LAP facilities, waste water (pink water) from the washing of equipment and buildings flows through ditches to outside concrete sumps. At Crane, the overflow from the sumps, goes to the natural watershed, rather than lagoons. The sludge from the sumps is removed periodically and taken to the burning ground for disposal by incineration.

The explosives loaded at Crane include the following: RDX, HMX, TNT, $NaNO_3$, NH_4NO_3, and ammonium picrate.

Active industrial discharges are tabulated below (14v):

Cast Loading Area 'A' - Up to three points discharging objectionable quantities of contaminants. Primarily TNT, RDX related, from rinses and washdowns. Immediate ground area heavily saturated with explosive contaminants.

Cast Loading of Area 'B' - Up to three or more points discharging objectionable quantities of contaminants. Primarily TNT, RDX related, from rinses and washdowns. Immediate ground area heavily saturated with explosive contaminants.

Bldg. 104 - Up to four points discharging objectionable quantities of contaminants. Primarily RDX and ammonium picrate process and rinse water, and water from phosphate coating operations.

Bldgs 107 & 107 - One point discharging objectionable effluent, highly caustic, containing undesirable amounts of oil, scum, and metals.

Bldg. 1884 - One point discharging objectionable effluent from plating operations: flow from rinse tanks, spills, and washdowns. Primarily oil, scum, and metals.

Rockeye Loading - Two points discharging effluent containing high concentrations of contaminants, primarily TNT and RDX related, from rinses and washdowns. Immediate ground area heavily saturated with explosive contaminants.

A large percentage of the airborne and waterborne explosive wastes generated from the bomb loading areas of Crane are discharged directly to the surrounding ground and nearby streams. High concentrations of explosives contaminants are retained in the soil as saturated surface water percolates through the various layers to the ground water table. During dry weather when all polluted effluent disappears below the stream bed, concentrations ranging from the limits of detection up to several milligrams per liter are found in nearby groundwater samples. During normal and wet seasons, contaminated waste water flows farther down the watershed, and dilution helps to lower the explosive concentrations significantly. Further natural aeration and stream actions generally lower explosive concentrations below detectable limits at the point where the stream leaves the base. Thus present deficiencies in treatment of industrial effluents at Crane are not greatly affecting the surrounding areas; but there is occurring a deterioration of the local environment, due to the unacceptable practice of using Boggs Reservoir, the natural streams, and surrounding land as a big wastewater treatment plant (14v).

EXPLOSIVES DISCHARGED DAILY TO THE ENVIRONMENT THRU WASTEWATER

-Lb. per Day-

Station	TNT	RDX	HMX	D	Loc.
TB04	4.8	-	.6	-	3 inch
S005	12.2	-	2.2	-	"
T014	3.7	4.8	.5	-	A Loading
B015	2.9	-	-	-	B Loading
B016	.5	1.0	.1	-	B "
B042	1.7	-	-	-	B "
B048	-	.5	.1	10.4	104
B049	-	1.3	-	9.6	104
B054	-	-	-	7.3	104

During the period Jan-Aug 1972, fifty points were monitored during multi-shift operations and high waste water loadings. No explosives (TNT, TDX, HMX or Ammonium Picrate) were found in detectable amounts in the waters leaving the military reservation. Only intermittent monitoring has taken place since 1972.

Three major abatement programs are planned:

- Wet scrubbers for TNT dust,
- Carbon columns for treatment of pink water, and
- Diversion of sump run-off water from the natural watershed to the sewage treatment plant, through settling basins.

(12) NAD Hawthorne (15zf). This is another Navy LAP plant which loads explosives only, by the melt-pour process. The explosives include: TNT and RDX, with formulations including Aℓ.

The volume of industrial process water ranges from 1 to 2 million gpd. The washings of buildings and equipment flow through ditches to outside sumps, and thence to pits for evaporation and percolation. Unlike most other LAP plants, Hawthorne is located in an arid area (Nevada) of high evaporation (80"/year), and disposal by evaporation is quite practical. The sludge is disposed of by burning.

The potable water supply is from reservoirs in the mountains above the reservation. Industrial waste water goes to some thirty pits for disposal. Essentially no monitoring has been conducted at Hawthorne of process waters.

NAD Hawthorne has been designated as the site of one of the two principal Navy demilitarization facilities, which is currently under development.

(13) NAD McAlester (15ag). Like Crane and Hawthorne, NAD McAlester is involved only in the loading of explosives, including TNT, RDX, HMX, NH_4NO_3, and ingredients such as $A\ell$, $CaC\ell_2$, and polymers. Both melt-pour and press-load processes are used. The waste waters from buildings and equipment flow through ditches to sumps, with overflow to evaporative lagoons. McAlester is located in Oklahoma, and the high evaporation rates make this method of disposal quite feasible.

There is no overflow from the evaporative lagoons. Weekly monitoring of six farm wells on the military installation and Brown Lake, as well as tap water result in no detectable levels of TNT, although the influent to the lagoons varies from 30-80 ppm TNT. The level of TNT in the lagoons is at 2-3 ppm.

The volume of industrial water in FY 1974 was about 650,000 gpd.

Monitoring of effluent in the depot areas during 1973-74 gave the following results (14x).

Depot Effluents (1973-74)

	Ave. (ppm)	Min. (ppm)	Max. (ppm)
Phosphate	4	0	6
Nitrate	6	1	12
BOD	4	1	6
Diss. Oxy.	9	3	12
TDS	150	75	225
Sulphate	25	0	50
Chloride	15	5	40

Although pink water is currently being treated at some LAP facilities by carbon columns, the Navy has been developing an "Oxidation Ditch" for biodegradation of TNT (see Chapter VI). NAD McAlester has been selected as the site for the installation of the first of these treatment facilities.

Analyses (14w) of Brown Lake, Sewage Effluent and Depot Effluent in July 1973 gave the following results.

Laboratory No.	S437	8438	8439
Sample	Brown Lake	Sewage Effluent	Depot Effluent*
pH	7.0	7.1	6.9
P Alkalinity as $CaCO_3$	None	None	None
M Alkalinity as $CaCO_3$	21.0 PPM	36.0 PPM	33.0 PPM
NO_3 (Nitrates)	0.89 PPM	16.83 PPM	1.33 PPM
PO_4 (Phosphates)	0.10 PPM	7.00 PPM	0.80 PPM
BOD	0.90 PPM	4.80 PPM	1.50 PPM
COD	3.37 PPM	3.37 PPM	5.03 PPM
Ammonia Nitrogen	0.08 PPM	0.15 PPM	0.03 PPM
Organic Nitrogen	1.10 PPM	0.90 PPM	0.90 PPM
Total Kjeldahl Nitrogen	1.18 PPM	1.05 PPM	0.98 PPM
Total Suspended Solids	10.50 PPM	12.00 PPM	17.50 PPM
Total Dissolved Solids	158.00 PPM	233.00 PPM	161.00 PPM
Total Solids	168.50 PPM	245.00 PPM	178.50 PPM
Total Volatile Solids	48.50 PPM	90.00 PPM	56.50 PPM

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*Bull Creek

(14) NWS Yorktown (152h). The fourth and last Navy LAP facility is at Yorktown, Va. Explosives, loaded by the melt-cast process include TNT, RDX and HMX. In addition to the melt-cast process, PBX formulations (RDX/HMX plus polymers) are filled using propellant-type blenders.

The industrial water volume is around 45,000 gal (max) per 8-hour shift for all of the three plant sites. Wash water from buildings goes to the usual concrete sumps, with overflow via storm drains to Lee Pond and, eventually to the York River. Sludge from the sumps goes to the burning grounds for disposal.

Well-water is monitored, with no detectable levels of explosives. Essentially no other monitoring data are available.

Plans are in preparation for installation of five waste water treatment facilities using carbon columns.

b. Summary of Wastewater Character

Table 48 summarizes the available information on LAP wastewater character presented above. Note that the data presented is insufficient to allow cross correlation.

c. Data Limitations

There is insufficient data to indicate the complete magnitude of discharges at LAP plants. The potential for groundwater infiltration of explosive and propellant wastes from evaporative ponds has not been fully investigated at every plant, and may be of some concern in some instances, but not in all.

TABLE 47
INDUSTRIAL WASTEWATER LOAD
TYPICAL SHELL/BOMB LOAD LINE 8
CAAP (1c(1))

Source	Volume (gpd)
Boiler Plant	525
Rod & Pellet Manufacturing	1,000
Explosive Pour Building	3,500
Screen Building	1,000
Cooling, X-ray, Storage	300
Total	6,325

TABLE 48
WASTEWATERS GENERATED IN LAP OPERATIONS

AAP	Activities	Raw Materials	Flow (gpd)	Pollutants	Discharge Load (lb/day)	Comments
CAAP	Load 8-inch shells	TNT	20,000[1]	57 mg/l TNT	~ 9.5(TNT)	Disposal in evaporation ponds
	Load 500-,750-, and 1,000-pound bombs	Tritonal (80% TNT and 20% flaked Al)				
	Laundry		14,500	2.7 mg/l TNT	~ .3(TNT)	Disposal in dry streams
	Overall		34,500		9.8(TNT)	
IAAP	Shell loading		90,000 (25,000)	Pink water 1 mg/l TNT[3] 145 mg/l RDX[2] 20 mg/l RDX[3]	.75(TNT)[3] 109(RDX)[2] 15 (RDX)[3]	Wastes subjected to diatomaceous earth filtration followed by adsorption on granular carbon columns
	Laundry		8,000	10 mg/l TNT	.67(TNT)[2]	Discharged to surface streams
	Mold booster charges from bulk explosives		215	Tetryl		
	Overall		98,000		1.42(TNT) 109(RDX)[2] 15(RDX)[3]	

TABLE 48

WASTEWATERS GENERATED IN LAP OPERATIONS

(continued)

AAP	Activities	Raw Materials	Flow (gpd)	Pollutants	Discharge Load (lb/day)	Comments
InAAP	Fabricate cloth bags and paper tubes and load propellants into these containers for shipment	N.A.[4]	N.A.[4]	N.A.[4]	N.A.[4]	
JAAP	Loading of medium caliber ammunition and ammunition components	Composition-B being loaded into 105 mm shells at a rate of 200,000 shells per month	6,200	TNT 145 mg/l RDX[2] 20 mg/l RDX[3]	7.5(RDX)[2] 1.0(RDX)[3]	Filtered through diatomaceous earth and then through two granulated charcoal
KAAP	Load explosives, primarily formulations of TNT and RDX, into ordnance items	TNT, RDX	N.A.[4]	TNT, RDX	N.A.[4]	Currently wastewaters are disposed of by trucking them to evaporative ponds
	Detonators for 105 mm howitzer shells	Lead azide, lead styphnate, RDX	N.A.[4]	N.A.[4]		$NaNO_3$, acetic acid, and NaOH used to deactivate the lead azide

TABLE 48
WASTEWATERS GENERATED IN LAP OPERATIONS
(continued)

AAP	Activities	Raw Materials	Flow (gpd)	Pollutants	Discharge Load (lb/day)	Comments
LSAAP	Melt-pour (Area O)	Composition-B	N.A.^{4,5}	Pink Water NO_3,TOC,color,TNT, pH	N.A.^{4}	Discharged to lagoon system
	Melt-pour (Area C)	Composition-B				
	Melt-pour (Area E)	TNT and Composition-B	20,000^{5}	Pink Water NO_3,TOC,color,TNT, pH	N.A.^{4}	Recycled
	Melt-pour (Area G)	Octyl,TNT, and Composition-B				
	Load Line (Area P)	Lead azide	N.A.^{4,6}	N.A.^{4}	N.A.^{4}	Batch destruction by use of cerric ammonium nitrate
	Load Line (Area Q)	Lead azide	N.A.^{4,6}	N.A.^{4}	N.A.^{4}	
	Black-powder load	Black powder	None except raw sewage and storm-water runoff	N.A.^{4}	N.A.^{4}	Spilled powder is dumped into surface waters
LHAAP	Mixing, processing and loading of propellants for rocket projectiles	N.A.^{4}	N.A.^{4}	BOD,COD,Mn,CN-,NO_3 PO ,Fe,Cd,polysulfide polymers, aluminum powder, black powder, and ammonium perchlorate	N.A.^{4}	Ammonium perchlorate goes to surface water. All solids go to evaporative ponds and are eventually incinerated. Remaining wastes go to surface water

TABLE 48
WASTEWATERS GENERATED IN LAP OPERATIONS
(continued)

AAP	Activities	Raw Materials	Flow (gpd)	Pollutants	Discharge Load (lb/day)	Comments
LAAP	Shell-loading	N.A.[4]	138,000	80 mg/1 TNT	92(TNT)	Waste is trucked to leaching ponds on the plant grounds
MAAP	N.A.[4]	N.A.[4]	400,000	.5 mg/1 RDX 1.0 mg/1 TNT	2.0(RDX) 3.0(TNT)	Wastewaters are discharged to a drainage canal which flows to surface water
	Shell washout	N.A.[4]	555	145 mg/1 RDX[2] 40 mg/1 TNT[2]	.7(RDX) .5(TNT)	
	Overall	N.A.[4]	400,000		2.7(RDX) 3.5(TNT)	
RaAAP	N.A.[4]	N.A.[4]	N.A.[4]	N.A.[4]	N.A.[4]	

TABLE 48
(continued)

[1] Primarily washdown waters

[2] Before treatment

[3] After treatment

[4] N.A. = not available

[5] Includes raw sewage and storm-water runoff

[6] Includes treated industrial sewage, raw sewage, and storm-water runoff

CHAPTER V

WASTEWATER CHARACTERIZATIONS

APPENDIX I

DETAILED DATA TABLES

TABLE I.A.1
CRUDE ACETIC ANHYDRIDE PRODUCTION. AREA A. HAAP
DIRECT DISCHARGE OF COOLING AND PROCESS WASTES TO THE HOLSTON RIVER FROM BUILDING 7 ld(2)

Parameter	Minimum	Maximum	Mean	Mean - Raw River		Discharge (lbs/day)	lbs of discharge * / ton of production
Temperature (°F)	68.0	74.0	70.8				
pH	7.30	8.40	7.70				
Conductance	163	229	187.5				
Nitrite and Nitrate as Nitrogen	0.9	1.6	1.2				
Kjeldahl Nitrogen as Nitrogen	< 0.5	1.1	0.12				
Total Filterable Phosphorus as Phosphorus	< 0.03	0.23	0.04				
Acidity as Calcium Carbonate	2.4	4.7	3.86	0.94		30.0	96×10^{-3} ↓
Alkalinity as Calcium Carbonate	75	80	76.1				
Total Solids	80	165	122	44		1,400	4,400
Suspended Solids	1.0	11.0	6.0	0.9		29	92
Dissolved Solids	68	164	116	43		1,380	4,360
Chemical Oxygen Demand	10	21	11				
Total Organic Carbon	4	13	6.5	0.5		16	50
Biological Oxygen Demand	1.0	3.0	2.0	2.0**		64	200
Sulfates	16.0	22.0	17.5	2.0		64	200
Phenols	< 0.05	0.16	0.05				
~~Acetic Acid~~	~~< 2.0~~	~~5.2~~	~~2.0~~				

Flow = 3.84 mgd; Production = 630,000 pounds acetic anhydride per day
*crude acetic anhydride produced; **no correction for raw river water

TABLE I.A.2

CRUDE ACETIC ANHYDRIDE PRODUCTION. AREA A. HAAP

DIRECT DISCHARGE OF COOLING AND PROCESS WASTES TO THE HOLSTON RIVER FROM BUILDING 7 1d(2)

Parameter	Minimum	Maximum	Mean	Mean - Raw River		Discharge (lbs/day)	lbs of discharge * / ton of production
Temperature (°F)	69.0	72.0	70.5				
pH	6.70	7.90	7.34				
Conductance	151	260	191				
Nitrite and Nitrate as Nitrogen	0.5	1.4	0.93				
Kjeldahl Nitrogen as Nitrogen	0.5	2.4	0.5				
Total Filterable Phosphorus as Phosphorus	0.03	0.67	0.06	0.02		0.59	1.88 x 10^{-3} ↓
Acidity as Calcium Carbonate	3.0	7.4	4.6				
Alkalinity as Calcium Carbonate	74	85	77.1				
Total Solids	64	180	126	48		1,400	4,600
Suspended Solids	3.5	19.5	9.1	4.0		120	380
Dissolved Solids	72	161.5	117.3	44.3		1,310	4,160
Chemical Oxygen Demand	< 10	18	10				
Total Organic Carbon	4	10	5.8				
Biological Oxygen Demand	< 1.0	< 1.0	< 1.0				
Sulfates	15.4	18.9	16.8	1.3		38.4	122
Phenols	< 0.05	< 0.05	< 0.05				
Acetic Acid	< 2.0	5.1	< 2.0				

Flow = 3.55 mgd; Production = 630,000 pounds acetic anhydride per day

*crude acetic anhydride produced

**corrected for Area A Holston Raw River Water

TABLE I.A.3

ACETIC ANHYDRIDE REFINING AND ACETIC ACID CONCENTRATION. AREA A. HAAP
LIQUID WASTES FROM BUILDINGS 6 AND 6A BEFORE ENTERING THE MAIN WASTE STREAM 1d(2)

Parameter	Minimum	Maximum	Mean	Mean - Raw River		Discharge (lbs/day)	lbs of discharge * / ton of production
Temperature (°F)	74.0	82.0	76.3				
pH	2.70	8.90	7.76				
Conductance	156	3,100	309				
Nitrite and Nitrate as Nitrogen	< 0.5	1.4	1.04				
Kjeldahl Nitrogen as Nitrogen	< 0.5	225	10.5	10.0		> 95.8	> 266 x 10^{-3}
Total Filterable Phosphorus as Phosphorus	0.07	793	34.6	33.9		325	902
Acidity as Calcium Carbonate	2.7	625	82.5	75.8		726	2,020
Alkalinity as Calcium Carbonate	0.0	80	66.3				
Total Solids	68	1,695	319	243		2,330	6,460
Suspended Solids	4.0	10.5	6.7	4.2		40	112
Dissolved Solids	61.5	213.5	121.7	47.7		457	1,270
Chemical Oxygen Demand	10	36	17.1	1.2		11.5	320
Total Organic Carbon	4	27	10.5	5.5		52.7	146
Biological Oxygen Demand	2.0	25.0	11.3	11.3**		108	300
Sulfates	10.0	127.0	31.2				
Phenols	< 0.05	< 0.05	< 0.05				
Acetic Acid	< 2.0	3.4	1.8				

Flow = 1.15 mgd; Production = 720,000 refined acetic anhydride per day

*refined acetic anhydride produced

**no correction for filtered raw river water

TABLE I.B.1
AMMONIUM NITRATE PRODUCTION. AREA B. HAAP
COOLING WATER FROM AMMONIA NITRATION IN BUILDING 330. ALSO OCCASIONAL RUNOFF FROM NITRIC ACID STORAGE AND DUMPS 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Temperature (°F)	6.4	79	71.9	60			
pH	6.6	8.6	7.83	7.43			
Conductance	340	740	540	284			
Ammonia as Nitrogen	0.62	2.46	1.63	1.02	0.61	9.40	47.0×10^{-3}
Nitrites and Nitrates as Nitrogen	1.3	7.0	2.66	0.8	1.86	28.7	144
Kjeldahl Nitrogen	0.8	5.8	2.40	1.28	1.12	17.2	86
Acidity	1.0	2.3	1.83	3.4			
Alkalinity	69	80	73.4	84.6			
Total Solids	313	451	406.4	207.5	198.9	3,060	15,300
Suspended Solids	4.8	18.0	9.12	10.2			
Dissolved Solids	307	496	397.2	197	200.2	3,080	15,400
Chemical Oxygen Demand	21	49	37	25	12	185	924
Total Organic Carbon	7	40	16.0	13	3	46.2	232
Biological Oxygen Demand	<5	12	5	4	.1	15.4	77.0

Flow = 1.85 mgd; Production = 400,000 pounds NH_4NO_3/HNO_3 solution/day
*NH_4NO_3/HNO_3 solution produced

TABLE I.C.1

AMMONIA RECOVERY. PRODUCT CONDENSER COOLING WATER (1.480 mgd), AMMONIA COLUMN BOTTOMS (0.032 mgd), PUMP SEAL WATER BUILDING A-1. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge* / ton of production
Temperature (°F)	50	72	60	60			
pH	7.7	8.2	7.95	7.43			
Conductance	540	790	686	284			
Ammonia as Nitrogen	1.05	1.98	1.34	1.02	0.32	4.02	.770
Nitrites and Nitrates as Nitrogen	0.9	1.4	1.23	0.8	0.43	5.41	.090
Kjeldahl Nitrogen as Nitrogen	1.7	2.5	1.93	1.28	0.65	8.18	1.36
Orthophosphate as Phosphorus	0.03	0.05	0.03	0.03			
Acidity as Calcium Carbonate	0.5	1.7	1.1	3.4			
Alkalinity as Calcium Carbonate	75	80	77.5	84.6			
Total Solids	444	530	487	207.5	279.5	3,520	586
Suspended Solids	5.0	7.2	6.1	10.2			
Dissolved Solids	437	525	481	197	284	3,570	596
Chemical Oxygen Demand	53	57	55	25	30	377	62.8
Total Organic Carbon	10	12	11	13			

Flow = 1.51 mgd; Production = 12000 lb/day anhydrous NH_3

*anhydrous NH_3 produced

TABLE I.C.2
NITRATION (HMX PRODUCTION). CATCH BASIN
BUILDING D-6 PROCESS WATER. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Influent							
Chemical Oxygen Demand			167	25	142	22.2	8.42
Total Carbon			35		35***	5.48	2.08
Organic Carbon			22		22***	3.44	1.31
Inorganic Carbon			13		13***	2.04	2.68
Nitrates			< 5.	0.8	< 4.2	< 0.658	.250
Effluent							
Chemical Oxygen Demand			98	25	73	11.4	4.32
Total Carbon			33		33***	5.17	1.96
Organic Carbon			19		19***	2.98	1.13
Inorganic Carbon			14		14***	2.19	.832
Nitrates			< 5	0.8	< 4.2	< 0.658	.250

Flow - 18,800 gpd; Production - 5,270 pounds HMX/day

*HMX produced
**not corrected for raw river water concentrations

TABLE I.C.3
NITRATION (RDX PRODUCTION). CATCH BASIN
BUILDING D-6 PROCESS WATER. AREA A. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Influent							
Biological Oxygen Demand			979	4	975	406	7.24
Chemical Oxygen Demand			1,177	25	1,152	480	8.54
RDX			2.1		2.1**	0.875**	0.015
HMX			0.9		0.9**	0.35**	0.006
Acetic Acid (100%)			160		160**	66.6**	1.19
Effluent							
Biological Oxygen Demand			878	4	874	364	6.48
Chemical Oxygen Demand				25			
RDX			0.96		0.96**	0.40**	.007
HMX			0.4		0.4**	0.167**	.003
Acetic Acid (100%)			160		160**	66.7**	1.19

Flow = 50,000 gpd; Production = 112,300 pounds RDX/day

*RDX produced

**not corrected for raw river water concentrations

TABLE I.C.4**
RECRYSTALLIZATION (RDX PRODUCTION). CATCH BASIN BUILDING G-2 PROCESS WATER. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Catch Basin Influent							
Biological Oxygen Demand				896		204	4.90
Chemical Oxygen Demand				463		106	2.54
Organic Carbon				234		53.4	1.28
Inorganic Carbon				22		5.02	0.120
Cyclohexanone				215		49.1	1.08
Catch Basin Effluent							
Biological Oxygen Demand				339		77.4	1.86
Chemical Oxygen Demand				403		92.0	2.20
Organic Carbon				217		49.5	1.19
Inorganic Carbon				23		5.25	0.126
Cyclohexanone				206		47.0	1.13

Flow = .0274; Production = 83,250 pounds RDX/day
*RDX produced
**no correction for raw water concentrations

TABLE I.C.5**
RECRYSTALLIZATION (RDX PRODUCTION). CATCH BASIN BUILDING G-6 PROCESS WATER. AREA B. HAAP ld(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge * / lbs of production
Catch Basin Influent							
Biological Oxygen Demand				332		376	
Chemical Oxygen Demand				1,240		1,404	
Organic Carbon				264		299	
Inorganic Carbon				9.7		11.0	
HMX				10.6		12.0	
RDX				5.0		5.66	
Acetone				81		91.8	
Cyclohexanone				587		665	
Toluene				2.7		3.06	
Butanol				81		91.8	
pH				6.1			
Catch Basin Effluent							
Biological Oxygen Demand				323		365	
Chemical Oxygen Demand				950		1,080	
Organic Carbon							
Inorganic Carbon				8.0		9.06	
HMX				4.4		4.98	
RDX				5.0		5.66	
Acetone				63		71.4	
Cyclohexanone				220		249	
Toluene				0.2		0.226	
Butanol				63		71.4	
pH				6.1			

Flow = .136 mgd; Production = not determined
*many products
**no correction for raw water

TABLE I.C.6*

GRINDING AND DEWATERING (RDX PRODUCTION). CATCH BASIN
BUILDING H-2. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge* / ton of production
Catch Basin Influent							
Biological Oxygen Demand			2,771			886	21.2
Chemical Oxygen Demand			4,292			1,370	32.8
RDX			49			15.7	0.376
HMX			1.5			0.480	0.011
Cyclohexanone			142			45.4	1.09
Acetic Acid			658			210	5.04
Catch Basin Effluent							
Biological Oxygen Demand							
Chemical Oxygen Demand							
RDX			33			10.6	254
HMX			0.7			0.224	5.38
Cyclohexanone							
Acetic Acid							

Flow = .0384 mgd; Production = 83,250 pounds/day RDX

*RDX produced

**no correction for raw water concentrations

TABLE I.C.7*

INCORPORATION (COMPOSITON-B PRODUCTION). CATCH BASIN

BUILDING I-2, AREA B, HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production **
Catch Basin Influent							
Chemical Oxygen Demand			384			381	1.38
RDX			3.1			3.10	0.011
TNT			6.3			6.29	0.023
HMX			<0.1			<1.00	<0.004
Organic Carbon			9.5			9.43	0.034
Inorganic Carbon			9.3			9.24	0.034
Total Carbon			17.2			17.1	0.062
Catch Basin Effluent							
Chemical Oxygen Demand						2.68	0.010
RDX			2.7			3.17	0.012
TNT			3.2			<0.060	<0.0003
HMX			<0.06				
Organic Carbon							
Inorganic Carbon							
Total Carbon							

Flow = .11926 mgd; Production = 550,000 lb/day (275 ton/day) Composition-B

*no correction for raw water concentrations

**Composition-B produced

TABLE I.C.8*
INCORPORATION: BED DRYING (COMPOSITION-B PRODUCTION)
BUILDING I-3. AREA B. HAAP 1d(2)

	Process Catch Basin No. 1	Process Catch Basin No. 2	Process Catch Basin No. 3	Scrubber Effluent Catch Basin
Chemical Oxygen Demand	40 ppm	32 ppm	32 ppm	18 ppm
Total Organic Carbon	13	8.0	11	5.0
Nitrites and Nitrates as Nitrogen	5.5	4.8	4.9	2.1
Total Kjeldahl Nitrogen as Nitrogen	2.5	2.3	2.0	1.7
RDX-insoluble	0	0	14.0	0
RDX-soluble	12.5	8.5	18.3	0
HMX-insoluble	0	0	11.2	0
HMX-soluble	5.1	1.0	4.2	0

Flow = 0.05 mgd overall; Production = 550,000 lb/day (275 ton/day) Composition-B produced.

*No correction for raw water concentrations.

TABLE I.C.9*
INCORPORATION: KETTLE DRYING (COMPOSITION-B PRODUCTION)
BUILDINGS L-5 AND M-5. AREA B. HAAP 1d(2)

	Scrubber Effluent Catch Basin (L-5)	Main Process Catch Basin (M-5)
Chemical Oxygen Demand	25	37
Total Organic Carbon	7.0	10
Nitrites and Nitrates as Nitrogen	1.4	1.7
Total Kjeldahl Nitrogen as Nitrogen	1.4	1.9
RDX-insoluble	0	
RDX-soluble	0	2.8
HMX-insoluble	0	
HMX-soluble	0	0

Flow = 0.0529 mgd overall; Production = 550,000 lb/day (275 ton/day) Composition-B produced.

*No correction for raw water concentrations.

TABLE I.C.10*
RECEIPT OF TNT (COMPOSITION-B PRODUCTION)
BUILDING K-1. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge** / ton of production (x 10^3)
Catch Basin No. 1 - Floor Wash Only (.00288 mgd)							
Chemical Oxygen Demand			31	25	6	0.864	23.6
Total Organic Carbon			17	13	4	0.576	15.8
Nitrites and Nitrates as Nitrogen			1.9	0.8	1.1	0.158	4.32
Total Kjeldahl Nitrogen as Nitrogen			1.8	1.28	1.5	0.216	5.92
Soluble RDX							
Soluble HMX							
TNT			36.4	36.4	0.0	5.24	144
Catch Basin No. 2 - Floor Wash & Scrubber Water (.0144 mgd)							
Chemical Oxygen Demand			86	25	61	8.78	240
Total Organic Carbon			40	13	27	3.89	107
Nitrites and Nitrates as Nitrogen			2.5	0.8	1.7	0.245	6.72
Total Kjeldahl Nitrogen as Nitrogen			3.0	1.28	1.7	0.245	6.72
Soluble RDX			2.8		2.8	0.403	11.04
Soluble HMX			0		0		
TNT							

Flow = .01728 mgd (.00288 mgd + .0144 mgd); Production = 73,000 pounds TNT/day
*corrected for raw water concentrations
**TNT produced (processed)

TABLE I.C.11
PACKAGING AND LOADING OF EXPLOSIVES (COMPOSITION-B PRODUCTION)
BUILDING N-6. AREA B. HAAP 1d(2)

Parameter	Expected Concentration Range
pH	7.0- 7.5
Chemical Oxygen Demand	15 - 636 ppm
Total Organic Carbon	1.0- 40 ppm
Biological Oxygen Demand	15 -2800 ppm
Nitrites and Nitrates as Nitrogen	1.0- 6.0 ppm
Total Kjeldahl Nitrogen as Nitrogen	1.0- 3.0 ppm

Flow = 74,880 gpd; Production = 550,000 lb/day (275 ton/day) Composition-B

TABLE I.D.1

ACETIC ACID CONCENTRATION. AREA A. HAAP. 42" OUTFALL FROM BUILDING 2 TO MAIN WASTE STREAM 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw Area A	Corrected Mean	Discharge (lbs/day)	lbs of discharge * / ton of production
Temperature (°F)	78.0	86.0	82.1				
pH	6.80	7.80	7.33				
Conductance	160	228	192				
$NO_2 + NO_3/N$	0.5	3.2	1.60	0.32		41	50×10^{-3}
Kjeldahl Nitrogen as Nitrogen	0.5	8.4	0.8	0.75		96	120
Total Filterable Phosphorus as Phosphorus	0.03	15.9	0.72	0.68		87	108
Acidity as Calcium Carbonate	2.0	8.3	5.9	1.1		140	176
Alkalinity as Calcium Carbonate	66	76	68.8				
Total Solids	112	156	132	54		6,900	8,600
Suspended Solids	3.0	21.0	7.6	2.5		320	400
Dissolved Solids	107	141	124	51.0		6,520	8,160
Chemical Oxygen Demand	79	128	103	89.0		11,400	14,200
Total Organic Carbon	30	50	35.0	29.0		3,710	4,640
Biological Oxygen Demand	>53	>79	>67	>67**		>8,566**	10,700
Sulfates	15.0	17.1	16.0	0.5		64	80
Phenols	<0.05	<0.05	<0.05				
Acetic Acid	<2.0	5.2	<2.0				

Flow = 15.35 mgd; Production = 1,600,000 lb 99+ acetic acid per day.
*99+ acetic acid produced; ** no correction for raw river water concentrations.

TABLE I.D.2

ACETIC ACID CONCENTRATION. AREA A. HAAP. 15" OUTFALL FROM BUILDING 2 TO MAIN WASTE STREAM 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw River Water	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production *
Temperature (°F)	43.0	66.0	61.5				
pH	6.50	8.40	7.75				
Conductance	154	225	186				
Nitrites and Nitrates as Nitrogen	0.9	1.6	1.29	0.01		0.03	0.04×10^{-3}
Kjeldahl Nitrogen as Nitrogen	0.5	1.2	0.5				
Total Filterable Phosphorus as Phosphorus	0.03	0.07	0.04				
Acidity as Calcium Carbonate	2.3	7.4	3.69				
Alkalinity as Calcium Carbonate	71	91	76.0				
Total Solids	90	191	137	59		180	220
Suspended Solids	1.5	17.0	5.4	0.3		0.90	1.12
Dissolved Solids	87.5	189.5	131.4	58.4		180	220
Chemical Oxygen Demand	10	25	16	2.0		6.0	7.4
Total Organic Carbon	4	11	6.4	0.4		1.2	1.48
Biological Oxygen Demand	< 1.0	2.0	1.0	1.0**		3.0	3.8
Sulfates	12.5	16.8	15.3				
Phenols	< 0.05	0.13	< 0.05				
Acetic Acid	< 2.0	15.0	2.9	> 0.9		2.7	3.4

Flow = .36 mgd; Production = 1,600,000 lb 99+ acetic acid per day.
*99+ acetic acid produced; **no correction for raw river water concentrations.

TABLE I.D.3

PRIMARY DISTILLATION. AREA B. HAAP. PRINCIPAL EFFLUENT FROM BUILDING B-11 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge * / ton of production
Temperature (°F)	65	72	68.9	60			
pH	6.8	8.2	7.68	7.43			
Conductance	340	675	461.1	284			
Ammonia as Nitrogen	0.73	1.98	1.24	1.02	0.22	20.5	27.2×10^{-3}
Nitrites and Nitrates as Nitrogen	0.7	5.6	1.72	0.8	0.92	85.7	114 ↓
Kjeldahl Nitrogen as Nitrogen	0.9	3.5	1.73	1.28	0.45	41.9	55.6
Orthophosphate as	< 0.03	0.07	< 0.03	< 0.03			
Acidity as Calcium Carbonate	0.8	2.0	1.6	3.4			
Alkalinity as Calcium Carbonate	74	91	79	84.6			
Total Solids	230	411	319	207.5	111.5	10,400	13,800
Suspended Solids	2.5	20.0	11.7	10.2	1.5	140	184
Dissolved Solids	223	397	307	197	110	10,200	13,500
Chemical Oxygen Demand	20	56	32	25	7	650	862
Total Organic Carbon	6	19	10	13			

Flow = 11.18 mgd; Production = 1,506,667 pounds 60 percent acetic acid per day.
*60% acetic acid produced

TABLE I.E.1

WASTEWATER FROM TWO CONDENSATE QUENCH POTS AND FOUR BAROMETRIC SEAL TANKS
BUILDING 334. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Ammonia as Nitrogen	0.22	1.60	0.53				
Nitrites and Nitrates as Nitrogen	12.0	60.0	29.2		28.4	423	2.75
Kjeldahl Nitrogen as Nitrogen	0.5	1.6	1.14				
Orthophosphate as Phosphorus	0.03	0.10	0.03				
Acidity as Calcium Carbonate	3.1	24	9.2		6.3	94	0.61
Alkalinity as Calcium Carbonate	0	65	21.1				
Total Solids	480	876	603		379	5,650	36.6
Suspended Solids	4.0	12.7	7.1		6.3	94	0.610
Dissolved Solids	473	866	596		373	5,560	36.1
Chemical Oxygen Demand	16	51	36		17.7	264	1.71
Total Organic Carbon	6	8	6.8				
Biological Oxygen Demand	<5	15	5		<5**	<75**	<0.49**

Flow = 1.79 mgd; Production = 307,000 lb/day (154 ton/day) 100% HNO_3
* 99% HNO_3 produced
**not corrected for filtered raw water - Area B, Holston River

TABLE I.E.2*
ACID AREAS 1 & 2. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			14,700 gpm				
pH			7.2				
Acidity as Calcium Carbonate			23			4,060	
Sulfates			373			65,800	
Nitrates as Nitrate			26			4,580	
Color (PCU)			5				

Flow = 21.168 mgd; Production = not available
*No correction for raw water values

TABLE I.E.3*
ACID 3 OUTFALL. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	$\frac{\text{lbs of discharge}}{\text{ton of production}}$
Average Flow			7,800 gpm				
pH Range			2.6-9.7				
Acidity as Calcium Carbonate			168			15,700	
Acidity Range			0-2389				
Sulfates			320			29,900	
Nitrates as Nitrate			30			2,810	
Color (PCU)			30				

Flow = 11.232 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.F.1*
ACID AREAS 1 & 2. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			14,700 gpm				
pH			7.2				
Acidity as Calcium Carbonate			23			4,060	
Sulfates			373			65,800	
Nitrates as Nitrate			26			4,580	
Color (PCU)			5				

Flow = 21.168 mgd; Production = not available

*No correction for raw water values

TABLE I.F.2*
ACID 3 OUTFALL. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			7,800 gpm				
pH Range			2.6-9.7				
Acidity as Calcium Carbonate			168			15,700	
Acidity Range			0-2389				
Sulfates			320			29,900	
Nitrates as Nitrate			30			2,810	
Color (PCU)			30				

Flow = 11.232 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.I.1
ACID NEUTRALIZATION PLANT EFFLUENT
"C" NITROCELLULOSE LINE. BAAP. 1a(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Flow	1.20	1.93	1.64	27.2			
Temperature (°F)	65	120	84.9				
pH	1.7	12.2	7.01	7.36			
Conductance	510	18,000	8,884.3				
Total Kjeldahl Nitrogen	1.3	3.4	2.17	2.28			
Ammonia	0.8	2.35	1.51	0.74	0.77	10.5	.233
Nitrates	50	600	434.1	0.63	434	5,930	132
Total Phosphates	< 0.5	0.85	0.593	0.63			
Sulfates	275	3,000	1,605.7	38	1.570	21,400	476
Chemical Oxygen Demand	57	111	83.1	45	38.1	520	11.6
Turbidity (JTU)	2.5	150	60.57	6.1			
Color (Platinum-Cobalt)	15	40	26.4	77			
Total Organic Carbon	22	78	37	27	10	137	3.04
Total Solids	396	9,141	5,516	200	5,316	72,600	1,610
Suspended Solids	9.6	646	286.7	13.7	273	3,730	82.9
Dissolved Solids	386.4	8,500	5,229.3	186	5,040	68,800	1,530
Iron	0.5	7.60	4.23	1.04	3.19	43.6	.969

Flow = 1.64 mgd; Production = 90,000 lb/day (45 ton/day) NC

TABLE I.I.2
ACID NEUTRALIZATION PLANT EFFLUENT
"B" NITROCELLULOSE LINE. BAAP. 1c(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Flow	2.54	3.55	3.12	27.2			
Temperature	60	> 120	75				
pH	0.9	12.4	11.7	7.36			
Conductance	760	> 18,000	10,205				
Total Kjeldahl Nitrogen	0.8	2.8	1.73	2.28			
Ammonia	0.38	1.4	0.89	0.74	0.15	3.90	.087
Nitrates	70	680	378.3	0.63	378	9,820	218
Total Phosphates	< 0.5	0.95	0.625	0.63			
Sulfates	103	2,175	1,103.8	38	1,066	27,700	616
Chemical Oxygen Demand	40	925	237.2	45	192	4,990	111
JTU	44	300	164.7	6.1			
Color (Platinum-Cobalt)	10	45	32.5	77			
Total Organic Carbon	21	50	34.7	27	7.7	200	4.44
Total Solids	1,162	10,024	6,522.1	200	6,322.1	164,000	3,640
Suspended Solids	149	948	571.7	13.7	558	14,500	322
Dissolved Solids	1,013	9,246	5,950.5	186	5,760	150,000	3,330
Iron	0.23	7.46	1.57	1.04	0.53	13.8	.307

Flow = 3.12 mgd; Production = 90,000 lb/day (45 ton/day) NC

TABLE I.I.3
POACHER PIT EFFLUENT
"C" NITROCELLULOSE LINE. BAAP la(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Flow	0.45	1.75	1.29	27.2			
Temperature	70	>120	83.6				
pH	1.5	6.9	5.43	7.36			
Conductance	410	4,100	932.9				
Total Kjeldahl Nitrogen	1.2	4.4	2.1	2.28			
Nitrates	7.1	31.8	14.8	0.63	14.2	152	3.38
Total Phosphates	<0.5	2.3	0.83	0.63	0.20	2.15	.048
Sulfates	63	195	128	38	90	967	21.5
Chemical Oxygen Demand	64	112	90	45	45	484	10.8
JTU	43	75	61	6.1			
Color (Platinum-Cobalt)	0	10	1.43	77			
Total Organic Carbon	35	66	48.5	27	21.5	231	5.13
Total Solids	340	542	440.7	200	240.7	2,590	57.6
Suspended Solids	63.5	138	104.6	13.7	91	978	21.7
Dissolved Solids	276	412	336	186	150	1,610	35.8

Flow = 1.29 mgd; Production = 90,000 lb/day (45 ton/day) NC

TABLE I.I.4

POACHER PIT EFFLUENT

"B" NITROCELLULOSE LINE. BAAP 1a(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Flow	0.13	2.34	1.02	27.2			
Temperature (°F)	82	> 120	93.4				
pH	5.3	8.4	7.01	7.36			
Conductance	450	900	584.3				
Total Kjeldahl Nitrogen	0.1	2.6	1.36	2.28			
Nitrates	3.8	12.5	7.6	0.63	7.0	59.5	1.32
Total Phosphates	< 0.5	27.2	4.81	0.63	4.2	35.7	.793
Sulfates	69	122	95	38	57	484	10.8
Chemical Oxygen Demand	43	2,100	750.9	45	706	6,000	133
JTU	5.0	12	8.13	6.1			
Color (Platinum-Cobalt)	10	65	27.9	77			
Total Organic Carbon	29	720	318.7	27	292	2,480	55.1
Total Solids	249	441	294.4	200	94.4	802	17.8
Suspended Solids	0	13.6	7.6	13.7			
Dissolved Solids	241	441	338.9	186	153	1,300	28.9

Flow = 1.02 mgd; Production = 90,000 lb/day (45 ton/day) NC

TABLE I.I.5
SOLVENT RECOVERY
STILL BOTTOMS. BAAP 1a(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Temperature	57	> 120	110				
pH	6.0	11.5	8.95	7.36			
Conductance	380	> 18,000	2,315.8				
Total Kjeldahl Nitrogen	1.0	19.4	5.57	2.28	3.29		
Nitrates	2.0	425	143.7	0.63	143.07		
Total Phosphates	0.8	15.3	4.99	0.63	4.36		
Sulfates	126	1,050	316.3	38	278.3		
Chemical Oxygen Demand	48	1,560	347.2	45	302.2		
JTU	102	520	261	6.1			
MBAS	0.50	0.90	0.70	0.16	0.54		
Total Organic Carbon	31	1,160	516.8	27	489.8		
Total Solids	612	4,639	1,885	200	1,685		
Suspended Solids	40.9	427	251	13.7	237.3		
Dissolved Solids	476	4,212	1,634	186	1,448		

Flow = not determined; Production = not determined

TABLE I.I.6*
NC PRODUCTION
BOILING TUB HOUSE. LINE A. DRAIN WHILE TUB IS FILLING. BLDG. 1019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			1.40				
Specific Conductance			36,700				
Suspended Solids			22.00			3.54	1.57
Total Organic Carbon			20.00			3.22	1.43
Fil-Chemical Oxygen Demand			56.00			9.00	4.00
NO_2-NO_3/N			460.00			84.0	37.4

Flow = .0193 mgd; Production = 4500 pounds HG-LG/NC/day Fil=Filtered
*No correction for raw water concentrations

TABLE I.I.7*
NC PRODUCTION
BOILING TUB HOUSE. LINE A. DRAIN AFTER ACID BOIL. BLDG 1019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	$\frac{\text{lbs of discharge}}{\text{ton of production}}$
pH			1.60				
Specific Conductance			13,300				
Suspended Solids			< 1.00			< 0.085	< .037
Total Organic Carbon			98.00			8.33	3.70
Fil Chemical Oxygen Demand			270.00			22.9	10.2
NO_2-NO_3/N			160.00			13.6	6.04

Flow = .0102 mgd; Production = 4500 pounds HG-LG/NC/day
*No correction for raw water concentrations

TABLE I.I.8*
NC PRODUCTION
BOILING TUB HOUSE. LINE A. DRAIN AFTER NEUTRAL BOIL. BLDG 1019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge/ton of production
pH			3.10				
Specific Conductance			620.00				
Suspended Solids			< 1.00			< 0.085	< 37.8
Total Organic Carbon			18.00			1.53	.680
Total Chemical Oxygen Demand			32.00			2.72	1.21
NO_2-NO_3/N			7.10			0.603	.268

Flow = .0102 mgd; Production = 4500 pounds HG-LG/NC/day
*No correction for raw water concentrations

TABLE I.I.9*
NC PRODUCTION
BOILING TUB HOUSE. LINE A. DRAIN AFTER NEUTRAL BOIL. BLDG 1019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			3.20				
Specific Conductance			800.00				
Suspended Solids			9.00			0.765	.340
Total Organic Carbon			22.00			1.87	.832
Fil Chemical Oxygen Demand			56.00			4.76	2.12
NO_2-NO_3/N			1,000.00			85.0	37.8

Flow = .0102 mgd; Production = 4500 pounds HG-LG/NC/day
*No correction for raw water concentrations

TABLE I.I.10*
NC PRODUCTION
WASTEWATER DRAIN LINE AT NORTHEAST END OF BOILING TUB HOUSE. LINE B. DRAIN WHILE TUB IS BILLING. BLDG 2019. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	1.10	3.93	2.24				
Specific Conductance	37,900.00	65,891.67	53,930.56				
Suspended Solids	11.60	62.53	34.88			135	2.12
Total Organic Carbon	0.00	148.00	90.56			350	5.52
Fil Chemical Oxygen Demand	151.00	151.00	151.00			583	9.20
Total Chemical Oxygen Demand	245.33	464.00	354.67			1,370	21.6
NO_2-NO_3/N	946.67	1,000.00	982.22			3,790	59.8

Flow = .4636 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.11*
NC PRODUCTION
WASTEWATER FROM BOILING TUB HOUSE. LINE B. DRAIN AFTER ACID BOIL. BLDG 2019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	1.30	2.00	1.70				
Specific Conductance	11,500	16,100.00	13,200.00				
Suspended Solids	<1.00	2.80	<1.77			<5.10	< .080
Total Organic Carbon	500.00	767.00	655.67			1,890	29.8
Total Chemical Oxygen Demand	1,280.00	1,984.00	1,661.33			4,780	75.4
NO_2-NO_3/N	9.00	220.00	79.33			228	3.6

Flow = .3458 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.12*

NC PRODUCTION

WASTEWATER FROM BOILING TUB HOUSE. LINE B. DRAIN AFTER NEUTRAL BOIL. BLDG 2019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	2.60	3.30	3.00				
Specific Conductance	375.00	1,210.00	721.33				
Suspended Solids	0.00	6.00	2.33			6.71	.106
Total Organic Carbon	34.00	91.00	59.00			170	2.68
Fil Chemical Oxygen Demand	152.00	152.00	152.00			438	6.92
Total Chemical Oxygen Demand	72.00	120.00	96.00			276	4.36
NO_2-NO_3/N	11.00	80.00	35.00			101	1.59

Flow = .3458 mgd; Production = 126,667 pounds NC/day

*No correction for raw water concentrations

TABLE I.I.13*
NC PRODUCTION
BOILING TUB HOUSE. LINE B. DRAIN AFTER NEUTRAL BOIL. BLDG 2019. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	2.90	3.40	3.15				
Specific Conductance	378.00	750.00	564.00				
Suspended Solids	1.00	1.80	1.40			4.03	.064
Total Organic Carbon	39.00	58.00	48.50			140	2.20
Fil Chemical Oxygen Demand	105.00	105.00	105.00			302	4.76
Total Chemical Oxygen Demand	140.00	140.00	140.00			403	6.36
NO_2-NO_3/N	12.00	13.60	12.80			36.9	.582

Flow = .3458 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.14*

NC PRODUCTION

DRAINLINE FROM TANK 4. BLDG 1022. JORDAN BEATER HOUSE. A-LINE. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			7.20				
Specific Conductance			798.00				
Suspended Solids			140.00			1.75	.778
Total Organic Carbon			7.0			0.087	.038
Total Chemical Oxygen Demand			144.00			1.80	.800

Flow = .0015 mgd; Production = 4500 pounds NC/day

*No correction for raw water concentrations

TABLE I.I.15*
NC PRODUCTION
DRAINLINE FROM TANK 4. BLDG 2022. JORDAN BEATER HOUSE. B-LINE. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.63	9.10	8.41				
Specific Conductance	179.00	480.00	279.67				
Suspended Solids	290.00	1,053.67	579.89			613	9.68
Total Organic Carbon	10.00	10.33	10.11			10.7	.169
Fil Chemical Oxygen Demand	31.00	31.00	31.00			32.8	.518
Total Chemical Oxygen Demand	272.00	544.00	416.00			440	6.94
NO_2-NO_3/N	0.60	4.03	2.21			234	3.70

Flow = .127 mgd; Production = 126,667 pounds NC/day (HG & LG)
*No correction for raw water concentrations

TABLE I.I.16*
NC PRODUCTION
POACHER BLENDER HOUSE. A-LINE. BLDG 1024. DECANT LINE FROM POACHER TUBS. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			9.00				
Specific Conductance			218.00				
Suspended Solids			52.00			0.412	.183
Total Organic Carbon			13.00			0.003	.046
Total Chemical Oxygen Demand			128.00			1.01	.448
NO_2-NO_3/N			1.10			0.0087	.004

Flow = .00095 mgd; Production = 4500 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.17*
NC PRODUCTION
POACHER BLENDER HOUSE. A-LINE. BLDG 1024. SECOND DECANT FROM POACHER TUBS. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			9.80				
Specific Conductance			208.00				
Suspended Solids			147.50			1.17	.520
Total Organic Carbon			13.00			0.103	.046
Total Chemical Oxygen Demand			192.00			1.52	.676
NO_2-NO_3/N			1.00			0.0079	.004

Flow = .00095 mgd; Production = 4500 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.18*
NC PRODUCTION
POACHER BLENDER HOUSE. A-LINE. BLDG 1024. TERTIARY DECANT FROM POACHER TUBS. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			9.80				
Specific Conductance			224.00				
Suspended Solids			125.00			0.739	.328
Total Organic Carbon			24.00			0.142	.063
Total Chemical Oxygen Demand			128.00			0.757	.336
NO_2-NO_3/N							

Flow = .00071 mgd; Production = 4500 pounds/day (LG & HG)
*No correction for raw water concentrations

TABLE I.I.19*

NC PRODUCTION

POACHER BLENDER HOUSE. A-LINE. BLDG 1024. DECANT AFTER 4 HOUR SODA BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			6.80				
Specific Conductance			826.00				
Suspended Solids			632.00			3.74	1.66
Total Organic Carbon			92.00			0.544	.242
Total Chemical Oxygen Demand			600.00			3.55	1.58
NO_2-NO_3/N			60.00			0.355	.158

Flow = .00071 mgd; Production = 4500 pounds NC/day

*No correction for raw water concentrations

TABLE I.I.20*
NC PRODUCTION
POACHER BLENDER HOUSE. A-LINE. BLDG 1024. DECANT.AFTER ONE HOUR WATER BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.60	6.70	6.65				
Specific Conductance	550.00	550.00	550.00				
Suspended Solids	318.00	558.00	438.00			2.11	.938
Total Organic Carbon	53.00	57.00	55.00			1.68	.746
Total Chemical Oxygen Demand	536.00	560.00	548.00			0.211	.094
NO_2-NO_3/N	34.00	51.00	42.50			0.163	.072

Flow = .00046 mgd; Production = 4500 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.21*

NC PRODUCTION

POACHER BLENDER HOUSE. A-LINE. BLDG 1024. DECANT AFTER ONE HOUR WATER BOIL. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.60	6.60	6.60				
Specific Conductance	450.00	550.00	450.00				
Suspended Solids	463.00	495.00	479.00				
Dissolved Solids	0.00	0.00	0.00				
Total Organic Carbon	41.00	45.00	43.00				
Total Chemical Oxygen Demand	456.00	552.00	504.00				
NO_2-NO_3/N	30.00	34.00	32.00				

Flow = not available; Production = 4500 pounds NC/day

*No correction for raw water concentrations

TABLE I.I.22*

NC PRODUCTION

POACHER BLENDER HOUSE. B-LINE. BLDG 2024. DECANT DRAINLINE FROM POACHER TUBS. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.30	9.00	7.92				
Specific Conductance	148.00	263.33	200.44				
Alkalinity	0.00	0.00	0.00				
Suspended Solids	23.93	258.00	142.98			94.6	1.51
Total Organic Carbon	14.00	27.00	18.67			12.5	.197
Fil Chemical Oxygen Demand	72.00	72.00	72.00			48.2	.760
Total Chemical Oxygen Demand	192.00	240.00	216.00			144	2.28
NO_2-NO_3/N	< 0.10	2.37	0.86			0.575	.009

Flow = .0803 mgd; Production = 126,667 pounds NC/day

*No correction for raw water concentrations

TABLE I.I.23*
NC PRODUCTION
POACHER BLENDER HOUSE. B-LINE. BLDG 2024. SECONDARY DECANT FROM POACHER TUBS. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.70	8.50	8.63				
Specific Conductance	150.00	264.00	190.33				
Suspended Solids	63.83	203.00	153.11			102	1.61
Total Organic Carbon	12.00	386.00	137.00			91.6	1.45
Fil Chemical Oxygen Demand	485.33	485.33	485.33			325	5.12
Total Chemical Oxygen Demand	160.00	184.00	172.00			115	1.82
NO_2-NO_3/N	0.57	1.10	0.86			0.575	.009

Flow = .0803 mgd; Production = 126,667

*No correction for raw water concentrations

TABLE I.I.24*
NC PRODUCTION
POACHER BLENDER HOUSE. B-LINE. BLDG 2024. DECANT AFTER FOUR HOUR BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.50	7.93					
Specific Conductance	484.00	1,020.00					
Suspended Solids	287.00	430.00				215	3.4
Total Organic Carbon	77.00	456.67				229	3.64
Fil Chemical Oxygen Demand	685.00	685.00				343	5.42
Total Chemical Oxygen Demand	424.00	704.00				352	5.56
NO_2-NO_3/N	11.00	40.00				20.0	.316

Flow = .0681 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.25*
NC PRODUCTION
POACHER BLENDER HOUSE. B-LINE. BLDG 2024. DECANT AFTER TWO HOUR WATER BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	5.80	6.70	6.13				
Specific Conductance	567.00	917.00	734.33				
Suspended Solids	56.50	526.00	258.33			129	2.04
Total Organic Carbon	81.00	140.00	103.67			569	.820
Total Chemical Oxygen Demand	248.00	688.00	464.00			232	3.66
NO_2-NO_3/N	47.00	70.00	55.33			27.7	.438

Flow = .0601 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.26*
NC PRODUCTION
POACHER BLENDER HOUSE. B-LINE. BLDG 2024. DECANT AFTER TWO HOUR WATER BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	5.60	6.90	6.10				
Specific Conductance	575.00	647.00	614.00				
Suspended Solids	78.00	363.00	195.33			97.8	1.54
Total Organic Carbon	82.00	91.00	86.33			43.2	.682
Total Chemical Oxygen Demand	212.00	512.00	334.67			168	2.66
NO_2-NO_3/N	40.00	50.00	43.67			21.9	.346

Flow = .0601 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.27*
NC PRODUCTION
POACHER BLENDER HOUSE. B-LINE. BLDG 2024. DECANT AFTER ONE HOUR WATER BOIL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	5.50	6.50	6.13				
Specific Conductance	343.00	500.00	407.67				
Suspended Solids	69.50	314.50	180.67			57.9	.914
Total Organic Carbon	58.00	85.00	68.67			22.0	.348
Total Chemical Oxygen Demand	216.00	268.00	236.00			75.7	1.20
NO_2-NO_3/N	25.00	43.00	33.00			10.6	.168

Flow = .0385 mgd; Production = 126,667 pounds NC/day
*No correction for raw water concentrations

TABLE I.I.28*
NC PRODUCTION
FINAL WRING HOUSE. A/B LINE. BLDG 1026. DRAINLINE FROM WRINGER HOUSE. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.40	8.20	7.73				
Specific Conductance	114.00	140.00	129.67				
Total Solids	442.00	1,462.00	794.00				
Suspended Solids	343.00	828.00	518.00				
Dissolved Solids	59.00	534.00	242.67				
Total Organic Carbon	10.00	30.00	18.33				
Fil Chemical Oxygen Demand	135.00	135.00	135.00				
Total Chemical Oxygen Demand	284.00	784.00	534.00				

Flow = not available; Production = 131,167 pounds NC/day (HG & LG)
*No correction for raw water concentrations

TABLE I.I.29*
ALCOHOL RECTIFICATION
STILLHOUSE. BLDG 1502. WASTE "SLOP" FROM SAMPLING SPIGOT OF STILL. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.70	7.40	7.10				
Specific Conductance	10.00	20.00	15.00				
Acidity	2.00	12.00	7.00			1.23	.008
Alkalinity	27.00	465.00	246.00			43.2	.298
Total Solids	25.00	98.00	49.67			8.73	.060
Suspended Solids	3.00	12.00	7.17			1.26	.008
Dissolved Solids	14.00	68.00	34.67			6.09	.042
Total Volatile Solids	25.00	68.00	39.67			6.97	.048
Color	28.00	28.00	28.00				
Total Organic Carbon	15.00	40.00	29.67			5.21	.036
Total Chemical Oxgen Demand	32.00	144.00	104.00			18.3	.126
Biological Oxygen Demand	24.00	78.00	44.67			7.85	.054
Kjeldahl Nitrogen	2.00	2.00	2.00			.351	.002
Nitrite and Nitrate-Nitrogen	3.00	3.00	3.00			.527	.004
Sulfates	.00	.00	.00			-0-	-0-

Flow = 21,100 gpd; Production = 290,356 pounds weak alcohol processed/day

*No correction for raw water concentrations

TABLE I.I.30*

ALCOHOL RECTIFICATION

STILLHOUSE. BLDG 1502. COOLING WATER FROM COOLING WATER DISCHARGE LINE AT BOTTOM OF STILL IN BLDG 1502. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.20	9.70	8.73				
Secific Conductance	110.00	189.00	143.67				
Total Solids	111.00	129.00	117.67			421	2.90
Suspended Solids	< 1.00	15.00	< 6.50			< 23.3	< .160
Dissolved Solids	98.00	129.00	111.33			399	2.74
Total Organic Carbon	5.00	6.00	5.67			20.3	.140
Filtered Chemical Oxygen Demand	13.00	14.00	13.67			49.0	.338
Kjeldahl Nitrogen	.70	.70	.70			2.51	.017
Nitrite and Nitrate-Nitrogen	2.10	2.10	2.10			7.52	.052

Flow = .43 mgd; Production = 290,356 pounds weak alcohol processed

*No correction for raw water concentrations

TABLE I.I.31*
ALCOHOL RECTIFICATION
STILLHOUSE. BLDG 1502. WASTE SLOP FROM SPIGOT AT BOTTOM OF STILL IN STILLHOUSE. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.50	9.00	7.40				
Specific Conductance	1,000.00	2,140.00	1,396.67				
Acidity	0.00	12.00	7.33			0.528	.004
Alkalinity	175.00	700.00	371.67			26.7	.187
Total Solids	4,060.00	5,997.00	5,146.67			370	2.58
Suspended Solids	2,264.00	2,545.00	2,451.33			176	1.23
Dissolved Solids	1,796.00	3,452.00	2,695.33			194	1.36
Total Organic Carbon	500.00	1,240.00	824.33			59.3	.414
Filtered Chemical Oxygen Demand	3,400.00	3,640.00	3,520.00			253	1.77
Biological Oxygen	185.00	>350.00	295.00			21.2	.148

Flow = .00864 mgd; Production = 286,216 pounds weak alcohol processed/day
*No correction for raw water concentrations

TABLE I.I.32*
ALCOHOL RECTIFICATION
COOLING WATER DISCHARGE LINE IN BLDG 1503. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.80	9.60	9.17				
Specific Conductance	109.00	150.00	131.33				
Total Solids	112.00	215.00	164.00			587	4.38
Suspended Solids	<1.00	3.80	<2.20			<7.88	< .005
Dissolved Solids	110.00	211.00	161.67			579	4.32
Total Volatile Solids	28.00	77.00	52.50			188	1.40
Color	5.00	28.00	12.67			45.4	.340
Total Organic Carbon	5.00	6.00	5.67			20.3	.151
Filtered Chemical Oxygen Demand	14.00	17.00	15.67			56.1	.418
Kjeldahl Nitrogen	0.50	0.50	0.50			1.79	.013
Nitrite and Nitrate-Nitrogen	3.10	3.10	3.10			39.8	.296

Flow = .43 mgd; Production = 268,216 pounds weak alcohol processed/day
*No correction for raw water concentrations

TABLE I.J.1
NITROGLYCERIN PLANT EFFLUENT
BAAP 1a(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Flow	0.06	0.17	0.11	27.2			
Temperature	50	67	58.3				
pH	1.7	9.5	4.74	7.36			
Conductance	400	8,000	2,720				
Total Kjeldahl Nitrogen	1.1	5.1	2.54	2.28	0.26	0.238	.018
Ammonia	0.85	3.05	1.66	0.74	0.92	0.843	.066
Nitrates	0.5	200	116.6	0.63	115.97	106	8.28
Total Phosphates	<0.5	2.0	1.21	0.63	0.58	0.531	.041
Sulfates	62	415	242.6	38	204.6	187	14.6
Chemical Oxygen Demand	18	340	109.1	45	64.1	58.7	4.58
Total Organic Carbon	19	56	35.3	27	8.3	7.60	.594
Lead	0.05	1.29	0.73		0.73*	0.669*	.052
Iron	0.24	0.55	0.40	1.04			

Flow = 0.11 mgd; Production = 25% capacity = 25,600 lb/working day (12.8 ton/day) NG
*not corrected for raw water concentrations

TABLE I.J.2*
NG PRODUCTION
COMBINED FLOW OF NITRATOR BLDG AND COOLING WATER. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Temperature (°F)	62.0	80.0	71.6				
pH	8.8	9.9	9.4				
Specific Conductance	182.0	11,500.00	4,732.0				
Acidity	0.0	0.0	0.0				
Alkalinity	99.0	6,900.0	2,100.7			936	226
Total Solids	111.0	25,358.0	8,149.5			3,630	874
Suspended Solids	< 1.0	39.0	< 6.4			< 2.85	< .686
Dissolved Solids	111.0	25,351.0	8,143.0			3,630	874
Color	5.0	80.0	19.0				
Total Organic Carbon	5.0	420.0	86.0			38.3	9.22
Fil Chemical Oxygen Demand	< 10.0	195.0	< 81.7			< 36.4	< 8.78
Kjeldahl Nitrogen	< 0.5	6.0	< 1.6			< 0.713	< .172
NO_2-NO_3/N	0.3	1,920.0	458.2			204	49.2
Sulfates	14.0	466.0	145.4			64.8	15.6
Nitroglycerin	0.0	315.0	105.7			47.1	11.3

Flow =.0535; Production = 8300 pounds/day (4.15 ton/day) NG
*No correction for raw water concentrations

TABLE I.J.3*

NG PRODUCTION

TOP PIPE ENTERING CATCH TANK NO. 12 CARRYING AMMONIA COMPRESSOR WATER. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.70	10.70	9.03				
Specific Conductance	170.00	583.00	386.00				
Acidity	0.00	2.00	0.67				
Alkalinity	55.00	233.00	124.00				
Total Solids	273.00	491.00	382.00				
Suspended Solids	2.60	5.50	4.05				
Dissolved Solids	267.00	488.00	377.50				
Fil Chemical Oxygen Demand	< 10.00	27.00	15.67				
Biological Oxygen Demand	0.00	6.00	3.33				
Kjeldahl Nitrogen	0.00	0.50	0.25				
NO_2-NO_3/N	5.20	5.20	5.20				
Nitroglycerin	0.00	0.00	0.00				

Flow = not available; Production = not available

*No correction for raw water concentrations

TABLE I.J.4*
NG PRODUCTION
EFFLUENT FROM CATCH TANK RECEIVING WASTES FROM NITRATION BLDG 9463. NO. 2 AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.40	9.30	8.97				
Specific Conductance	1,650.00	31,000.00	13,550.00				
Acidity	0.00	0.00	0.00				
Alkalinity	410.00	15,100.00	6,310.00			93.3	22.4
Total Solids	2,041.00	70,775.00	25,028.33			370	89.2
Suspended Solids	< 1.00	63.30	< 24.20			< 0.358	.086
Dissolved Solids	2,033.00	70,712.00	25,004.67			370	89.2
Filtered Chemical Oxygen Demand	41.00	1,400.00	567.00			8.38	2.02
Kjeldahl Nitrogen	< 0.50	< 0.50	< 0.50			< 0.00739	< .002
Nitrite and Nitrate-Nitrogen	250.00	250.00	250.00			3.70	.892
Sulfates	15.20	535.00	238.40			3.52	.848
Nitroglycerin	0.00	32.00	12.33			0.182	.044

Flow = .001775 mgd; Production = 8300 pounds/day (4.15 ton/day) NG
*No correction for raw water concentrations

TABLE I.J.5*
NG PRODUCTION
BOTTOM PIPE IN CATCH TANK NO. 12 CARRYING COOLING WATER FROM AIR COMPRESSOR BLDG 9467. NG NO. 2 AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.20	9.20	8.77				
Specific Conductance	210.00	465.00	305.67				
Acidity	0.00	0.00	0.00				
Alkalinity	80.00	107.00	91.33				
Total Solids	127.00	628.00	337.67				
Suspended Solids	< 1.00	4.50	<2.83				
Dissolved Solids	124.00	628.00	335.00				
Filtered Chemical Oxygen Demand	24.00	148.00	68.67				
Kjeldahl Nitrogen	<0.50	<0.50	< 0.50				
Nitroglycerin	0.00	0.00	0.00				

Flow = not available; Production = not available

*No correction for raw water concentrations

TABLE I.J.6*
NG PRODUCTION
EFFLUENT FROM FINAL CATCH TANK OF NITROGLYCERIN STOREHOUSE BLDG 9472. PREMIX NO. 2 AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	10.40	11.00	10.63				
Specific Conductance	1,280.00	8,100.00	5,393.33				
Acidity	0.00	0.00	0.00				
Alkalinity	952.00	11,700.00	6,717.33			48.1	34.8
Total Solids	1,304.00	8,006.00	4,088.33			29.3	21.2
Suspended Solids	3.30	16.30	9.20			0.0660	.048
Dissolved Solids	1,301.00	7,998.00	4,079.33			29.2	21.2
Total Organic Carbon	31.00	630.00	330.50			2.37	1.71
Filtered Chemical Oxygen Demand	74.00	815.00	449.67			3.22	2.34
Kjeldahl Nitrogen	< 0.50	< 0.50	< 0.50			< 0.00359	< .003
Nitrite and Nitrate-Nitrogen	19.00	19.00	19.00			0.136	.098
Nitroglycerin	0.00	83.00	48.00			0.344	.248

Flow = .000861; Production = 2765 pounds/day (1.38 ton/day) NG processed
*No correction for raw water concentrations

TABLE I.J.7*
NG PRODUCTION
EFFLUENT FROM FINAL CATCH TANK OF NG MIXHOUSE BLDG 9473. PREMIX NO. 2 AREA. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.70	8.90	8.40				
Specific Conductance	271.00	295.00	282.00				
Acidity	.00	1.00	.33			.00550	< .001
Alkalinity	112.00	210.00	153.67			.256	.254
Total Solids	375.00	623.00	494.33			.824	.820
Suspended Solids	<1.00	24.30	<10.93			.0182	.018
Dissolved Solids	374.00	615.00	483.33			.805	.802
Color	8.00	8.00	8.00				
Total Organic Carbon	83.00	83.00	83.00			.138	.137
Filtered Chemical Oxygen Demand	64.00	400.00	221.33			.369	.368
Nitrite and Nitrate-Nitrogen	13.00	13.00	13.00			.0216	.021
Nitroglycerin	72.00	72.00	72.00			.120	.120

Flow = .0002 mgd; Production = 2008 pounds/day (1.00 ton/day) NG
*No correction for raw water concentrations

TABLE I.J.8*

NG PRODUCTION

EFFLUENT FROM PREMIX BLDG 9303-3 AND 9303-4, SOUTHEAST. PREMIX NO. 2 AREA, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
pH	7.30	9.40	8.23				
Specific Conductance	90.00	509.00	316.33				
Acidity	.00	3.00	1.33			.000665	.200
Alkalinity	53.00	265.00	158.33			.0791	24.0
Total Solids	145.00	941.00	518.00			.259	78.4
Suspended Solids	17.50	76.40	44.40			.0222	6.74
Dissolved Solids	69.00	923.00	473.67			.237	72.0
Total Volatile Solids	101.00	221.00	168.33			.0841	25.6
Total Organic Carbon	18.00	43.00	33.00			.0165	5.00
Filtered Chemical Oxygen Demand	60.00	60.00	60.00			.0300	9.10
Total Chemical Oxygen Demand	88.00	152.00	120.00			.0600	18.2
Biological Oxygen Demand	25.00	37.00	31.00			.0155	4.70
Kjeldahl Nitrogen	<.50	<.50	<.50			<.000250	< .076
Nitrite and Nitrate-Nitrogen	1.60	6.00	3.80			.00190	.576
Nitroglycerin	.00	40.00	13.33			.00667	2.04

Flow = .00006 mgd; Production = 6592 pounds/day (3.30 ton/day) NG

*No correction for raw water concentrations

TABLE I.L.1
OLEUM PRODUCTION
OLEUM DITCH NORTH OF PLANT. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean (A)	Mean Raw (B)	Corrected Mean (A-B)	Discharge (lbs/day)	lbs of discharge / ton of production **
Temperature (°F)	82.0	90.0	86.3	60			
pH	6.2	8.4	7.8	8.2			
Specific Conductance	337.0	2,625.0	911.3	475			
Acidity	0.0	28.0	8.0	4.0	4.0	33.7	.112
Alkalinity	148.0	348.0	224.3	124.0	100.3	846	2.82
Sulfates	109.0	168.0	133.4		133.4*	1,120*	3.73
T Hexane Extract	19.3	29.6	25.4		25.4*	214*	.713

Flow = 1.012 mgd; Production = 600,000 lb/day (300 ton/day) 40% oleum
*No correction for raw water concentrations; **100% oleum (40% actually produced)

TABLE I.L.2
OLEUM DITCH

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			7,340 gpm				
pH Range			2.3-9.8				
Acidity as Calcium Carbonate			17			1,500	
Acidity Range			0-275				
Sulfates			153			13,500	
Nitrates as Nitrate			31			2,730	
Color (PCU)			5				

Flow = 10.570 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.L.3
WASTEWATER FROM ACID TANK CAR DRAINING AS IT ENTERS OLEUM DITCH 1g(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / lbs of production
pH	7.3	7.9	7.6				
Specific Conductivity	6,144.0	6,144.0	6,144.0				
Acidity	.0	.0	.0				
Alkalinity	2,840.0	2,840.0	2,840.0				
Total Solids	6,412.0	6,637.0	6,474.0				
Suspended Solids	54.0	93.0	73.5				
Dissolved Solids	6,358.0	6,444.0	6,401.0				
Volatile Suspended Solids	105.6	105.6	105.6				
Total Organic Carbon	88.0	88.0	88.0				
Kjeldahl Nitrogen	17.0	711.0	364.0				
Sulfates	5,000.0	6,750.0	5,875.0				

TABLE I.N.1*
SINGLE BASE
INDUSTRIAL WASTE SEWER NORTH OF A-LINE SINGLE BASE PROPELLANT AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
Temperature (°F)	60.0	74.0	67.9				
pH	7.6	8.7	8.1				
Specific Conductance	70.0	203.0	110.8				
Acidity	0.0	3.0	0.7			0.222	6.34
Alkalinity	47.0	86.0	71.3			22.6	646
Total Solids	10.0	517.0	197.7			62.6	1788
Suspended Solids	<1.0	161.0	<9.7			<3.07	87.6
Dissolved Solids	10.0	513.0	188.3			59.6	1702
Total Volatile Solids	3.0	304.0	90.4			28.6	816
Color	5.0	28.0	11.3				
Total Organic Carbon	5.0	47.0	8.9			2.82	80.6
Filtered Chemical Oxygen Demand	<10.00	89.0	18.6			5.89	168.2
Kjeldahl Nitrogen	<0.5	2.9	0.9			0.285	8.14
Nitrite and Nitrate-Nitrogen	0.1	490.0	18.5			5.86	164.4
Sulfates	12.0	86.0	20.9			6.62	189.2
Diethyl Ether	<1.0	1.0	1.0			0.316	9.02
Ethyl Ether	<3.0	6.0	3.1			0.981	28.0

Flow = .038 mgd; Production = 70,000 pounds/day (35 ton/day) NC processed.
*No correction for raw water concentrations

TABLE I.N.2*
SINGLE BASE
SUMP TANK FOR HOLDING WASHDOWN WATER FROM DEHYDRATION BLDG 1500 - A-LINE SINGLE BASE PROPELLANT AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			7.50				
Specific Conductance			70.00				
Acidity			7.00				
Alkalinity			59.00				
Total Solids			78.00				
Suspended Solids			17.00				
Dissolved Solids			61.00				
Total Volatile Solids			23.00				
Color			28.00				
Total Organic Carbon			39.00				
Filtered Chemical Oxygen Demand			89.00				
Biological Oxygen Demand			118.00				
Kjeldahl Nitrogen			0.50				
Nitrite and Nitrate-Nitrogen			0.70				
Diethyl Ether			< 1.00				
Ethyl Ether			22.00				

Flow = .000061 mgd; Production = 59,320 pounds/day (29.7 ton/day) Single Base processed

*No correction for raw water concentrations

TABLE I.N.3*

SINGLE BASE

EFFLUENT PIPE CARRYING MIXHOUSE, WASHDOWN WATER AS IT ENTERS SEWER LINE NORTHWEST OF MIXHOUSE BLDG 1508, A-LINE, RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.70	6.90	6.80				
Specific Conductance	510.00	683.00	603.67				
Acidity	23.00	169.00	88.67				
Alkalinity	250.00	550.00	370.00				
Total Solids	1,572.00	3,493.00	2,223.67				
Suspended Solids	324.00	606.00	473.33				
Dissolved Solids	1,116.00	2,887.00	1,750.33				
Total Volatile Solids	27.00	8,828.00	968.00				
Color	130.00	600.00	410.00				
Total Organic Carbon	268.00	1,700.00	853.33				
Filtered Chemical Oxygen Demand	2,000.00	2,000.00	2,000.00				
Total Chemical Oxygen Demand	1,200.00	1,440.00	1,320.00				
Biological Oxygen Demand	>350.00	>350.00	>350.00				
Kjeldahl Nitrogen	6.90	11.80	8.90				
Nitrite and Nitrate-Nitrogen	1.00	6.00	3.67				
Diethyl Ether	43.00	189.00	116.00				
Ethyl Ether	54.00	1,853.00	953.00				
Acetone	4.30	4.30	4.30				
Dinitrotoluene	0.20	0.23	0.21				

Flow = .000091 mgd; Production = 70,000 pounds/day (35 ton/day) NC processed

*No correction for raw water concentrations

TABLE I.N.4*
SINGLE BASE
EFFLUENT PIPE FROM WASHDOWN WATER COLLECTION AS THE PIPE ENTERS THE CATCH TANK, SERVES BLDGS 1510, 1511, 1512, A-LINE, SINGLE BASE PROPELLANT AREA, RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.80	8.00	7.90				
Specific Conductance	89.00	215.00	152.00				
Acidity	0.00	2.00	1.00				
Alkalinity	63.00	200.00	131.00				
Total Solids	75.00	831.00	453.00				
Suspended Solids	2.30	435.00	218.65				
Dissolved Solids	73.00	396.00	234.50				
Color	10.00	80.00	45.00				
Total Organic Carbon	9.00	31.00	20.00				
Filtered Chemical Oxygen Demand	27.00	27.00	27.00				
Total Chemical Oxygen Demand	112.00	112.00	112.00				
Biological Oxygen Demand	100.00	100.00	100.00				
Kjeldahl Nitrogen	0.40	2.20	1.30				
Nitrite and Nitrate-	0.10	1.00	0.55				
Diethyl Ether	<1.00	<1.00	<1.00				
Ethyl Ether	<3.00	<3.00	<3.00				
Dinitrotoluene	0.94	0.94	0.94				

Flow = .000038 mgd; Production = 46,420 pounds/day (23.2 ton/day) single base processed

*No correction for raw water concentrations

TABLE I.N.5*
SINGLE BASE
EFFLUENT FROM CATCH TANK FOR WASHDOWN WATER NORTH OF PRESS AND CUTTING BLDG 1513, A-LINE, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	6.70	8.40	7.40				
Specific Conductance	121.00	327.00	196.67				
Acidity	4.00	28.00	15.00				
Alkalinity	79.00	303.00	156.33				
Total Solids	191.00	1,275.00	699.67				
Suspended Solids	50.00	1,275.00	463.33				
Dissolved Solids	0.00	583.00	236.33				
Color	14.00	105.00	73.00				
Total Organic Carbon	114.00	940.00	494.67				
Filtered Chemical Oxygen Demand	122.00	122.00	122.00				
Total Chemical Oxygen Demand	480.00	1,000.00	740.00				
Biological Oxygen Demand	> 140.00	> 140.00	> 140.00				
Kjeldahl Nitrogen	0.90	5.10	2.87				
Nitrite and Nitrate-Nitrogen	< 0.10	5.00	< 1.80				
Diethyl Ether	3.00	341.00	155.67				
Ethyl Ether	52.00	994.50	514.83				
Acetone	1.20	3.25	2.22				
Dinitrotoluene	0.19	0.23	0.21				

Flow = .000091 mgd; Production = 33,259 pounds/day (16.6 ton/day) single base processed

*No correction for raw water concentrations

TABLE I.0.1*

MULTIBASE

WASHDOWN WATER AS IT ENTERS THE CATCH TANK SOUTH OF BLDG 4906 (MIXHOUSE), C-LINE, MULTIBASE AREA, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
pH	8.10	8.40	8.25				
Specific Conductance	115.00	165.00	140.00				
Acidity	0.00	1.00	0.50			0.000833	.276
Alkalinity	71.50	77.00	74.25			0.124	79.4
Total Solids	317.50	1,677.00	997.25			1.66	548
Suspended Solids	20.00	67.00	43.50			0.0725	24
Dissolved Solids	297.50	1,610.00	953.75			1.59	526
Total Volatile Solids	128.50	1,136.00	632.25			1.05	348
Color	5.00	5.00	5.00				
Total Organic Carbon	7.00	188.00	97.50			0.162	53.6
Filtered Chemical Oxygen Demand	17.00	268.00	142.50			0.237	78.2
Biological Oxygen Demand	15.00	15.00	15.00			0.0250	8.26
Kjeldahl Nitrogen	0.90	270.00	135.45			0.226	74.8
Nitrite and Nitrate-Nitrogen	0.25	17.30	8.77			0.0146	4.82
Nitroglycerin	0.00	0.00	0.00			0	0

Flow = .0002 mgd; Production = 6050 pounds/day (3.02 ton/day) M-30

*No correction for raw water concentrations

TABLE I.0.2*
MULTIBASE
EFFLUENT FROM CATCH TANK SOUTH OF BLDG 4906 (MIXHOUSE) C-LINE, MULTIBASE AREA, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
pH	8.00	8.70	8.35				
Specific Conductance	110.00	145.00	127.50				
Acidity	1.00	2.00	1.50			0.00250	.826
Alkalinity	60.00	76.00	68.00			0.113	37.4
Total Solids	347.00	624.00	485.50			0.809	268
Suspended Solids	28.00	28.00	33.00			0.0550	18.2
Dissolved Solids	319.00	596.00	457.50			0.762	252
Total Volatile Solids	273.00	409.00	341.00			0.568	188
Color	5.00	10.00	7.50				
Total Organic Carbon	24.00	46.00	35.00			0.0583	19.3
Filtered Chemical Oxygen Demand	31.00	40.00	35.50			0.0591	19.5
Biological Oxygen Demand	14.00	35.00	24.50			0.0408	13.5
Kjeldahl Nitrogen	39.00	66.00	52.50			0.0875	19.0
Nitrite and Nitrate-Nitrogen	4.90	7.00	5.95			0.00991	3.28

Flow = .0002 mgd; Production = 6050 pounds/day (3.02 ton/day) M-30

*No correction for raw water concentrations

TABLE I.0.3*
MULTIBASE
WASHDOWN WATER ENTERING THE CATCH TANK SERVING THE HIGH ENERGY MIXHOUSE, BLDG 3692, C-LINE, MULTIBASE AREA, RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH			7.30				
Specific Conductance			285.00				
Acidity			3.00				
Alkalinity			67.00				
Total Solids			350.00				
Suspended Solids			31.00				
Dissolved Solids			319.00				
Total Volatile Solids			155.00				
Color			150.00				
Total Organic Carbon			300.00				
Filtered Chemical Oxygen Demand			510.00				
Biological Oxygen Demand			> 140.00				
Kjeldahl Nitrogen			16.00				
Nitrite and Nitrate-Nitrogen			2.00				

Flow = not available; Production = not available

*No correction for raw water concentrations

TABLE I.0.4*
MULTIBASE
EFFLUENT CATCH TANK RECEIVING WATER FROM PRESS AND CUTTING BLDG 3514, C-LINE, MULTIBASE AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
pH	7.70	8.00	7.85				
Specific Conductance	33.00	75.00	54.00				
Acidity	2.00	5.00	3.50			0.0105	.726
Alkalinity	27.00	40.00	33.50			0.100	6.92
Total Solids	57.00	57.00	57.00			0.171	11.8
Suspended Solids	12.50	25.00	18.75			0.056	3.88
Dissolved Solids	44.00	44.00	44.00			0.132	9.12
Total Volatile Solids	26.00	26.00	26.00			0.0780	5.40
Total Organic Carbon	23.00	32.00	27.50			0.0825	5.70
Filtered Chemical Oxygen Demand	43.00	137.00	90.00			0.270	18.7
Biological Oxygen Demand	49.00	49.00	49.00			0.147	10.2
Kjeldahl Nitrogen	1.50	1.60	1.55			0.00465	.322
Nitrite and Nitrate-Nitrogen	0.70	0.80	0.75			0.00225	.156
Nitroglycerin	0.00	0.00	0.00			0	0

Flow = .0029988; Production = 28,930 pounds/day (14.5 ton/day) M-30

*No correction for raw water concentrations

TABLE I.0.5*

MULTIBASE

INFLUENT TO SAND FILTER NORTH OF AP CHEMICAL GRIND, BLDG 3670, MULTIBASE AREA, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	7.90	8.70	8.37				
Specific Conductance	205.00	12,500.00	4,306.67				

Flow = not available; Production = not available
*No correction for raw water concentrations

TABLE I.0.6*
MULTIBASE
WASHDOWN WATER FROM HE SLURRY MIXHOUSE, BLDG 3671, AS IT LEAVES CATCH TANK, C-LINE, MULTIBASE AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge/ton of production
pH	7.50	7.70	7.57				
Specific Conductance	8,300.00	13,500.00	10,633.00				
Color	15.00	25.00	20.00				
Total Organic Carbon	3,500.00	5,300.00	4,600.00			13.8	9.72

Flow = .00036 mgd; Production = 2835 pounds/day (1.42 ton/day) Sprint ABL 2901 DQ/D

*No correction for raw water concentrations

TABLE I.P.1
ROLLED POWDER
FLOW IN GENERAL PURPOSE SEWER SERVING PREROLL, ETC., IN THE FOURTH ROLLED POWDER AREA PRIOR TO DISCHARGE TO SETTLING BASIN
RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Temperature (°F)	59.0	78.0	68.2				
pH	7.8	10.0	8.9				
Specific Conductance	109.0	636.0	383.3				
Acidity	0.0	2.0	0.1			0.0332	.012
Alkalinity	91.0	369.0	223.2			74.2	27.4
Total Solids	115.0	1,047.0	468.6			156	57.8
Suspended Solids	< 1.0	18.6	6.9			2.29	.848
Dissolved Solids	96.0	1,039.0	461.9			154	57.0
Total Volatile Solids	10.0	443.0	148.5			49.4	18.3
Color	5.0	40.0	12.0				
Total Organic Carbon	6.0	40.0	13.5			4.49	1.66
Filtered Chemical Oxygen Demand	14.0	102.0	31.4			10.4	3.84
Biological Oxygen Demand	1.0	34.0	7.9			2.62	.970
Kjeldahl Nitrogen	0.5	4.0	1.0			0.332	.123
Nitrite and Nitrate-Nitrogen	< 0.1	7.9	1.6			0.532	.197
Sulfates	14.0	37.0	22.5			7.48	2.76

Flow = .0399 mgd; Production = 5400 pounds/day (2.70 ton/day) propellant

TABLE I.P.2

ROLLED POWDER

EFFLUENT CHANNEL FROM FINAL CATCHBASIN SERVING THE BLENDING BLDG NO. 6304 IN THE FIRST ROLLED POWDER AREA, RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge ton of production
Temperature (°F)			56.0				
pH			8.4				
Specific Conductance			130.0				
Acidity			0.0				
Alkalinity			61.0			21.7	8,68
Total Solids			128.0			45.6	18.2
Suspended Solids			9.5			3.39	1.36
Dissolved Solids			118.0			42.0	16,8
Total Volatile Solids			92.0			32.8	13.1
Total Organic Carbon			11.0			3.92	1.56
Biological Oxygen Demand			6.0			2.14	.856
Kjeldahl Nitrogen			1.1			0.392	.157
Sulfates			16.8			5.99	2.40

Flow = .0428 mgd; Production = 5000 pounds/day (2.5 ton/day) M-8 propellant

TABLE I.P.3
ROLLED POWDER
DISCHARGE GUTTERS ENTERING CATCHTANK SOUTH OF PREROLL BLDG 9309-4, FOURTH ROLLED POWDER AREA (INDIVIDUAL BAY WASHDOWNS SAMPLED)
RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.70	11.60	10.36				
Specific Conductance	135.00	3,690.00	1,085.43			16.7	18.6
Total Solids	280.00	5,462.00	1,761.71			1.70	1.89
Suspended Solids	29.00	402.00	179.29			1.30	1.44
Total Organic Carbon	11.00	566.00	137.14			1.87	
Filtered Chemical Oxygen Demand	38.00	731.00	197.14				

Flow = .00114 mgd; Production = 1800 pounds per day (.9 ton/day) propellant

TABLE I.P.4
ROLLED POWDER
WASHWATER TROUGH LEADING IN FROM BLENDER BLDG 6304, FIRST CATCH BASIN, FIRST ROLLED POWDER AREA. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	$\frac{\text{lbs of discharge}}{\text{ton of production}}$ $(\times 10^3)$
pH	7.40	8.90	7.87				
Specific Conductance	115.00	136.00	127.50				
Total Solids	109.00	174.00	127.00			3.24	432
Suspended Solids	1.30	23.00	6.90			0.176	23.4
Dissolved Solids	108.00	151.00	120.25			3.07	410
Total Organic Carbon	4.00	11.00	7.25			0.185	24.6
Filtered Chemical Oxygen Demand	< 10.00	16.00	11.50			0.294	39.2
Biological Oxygen Demand	1.00	12.00	4.50			0.115	15.3
Nitrite and Nitrate-Nitrogen	0.10	0.10	0.10			0.00255	.34

Flow = .003066 mgd; Production = 15000 pounds/day (7.5 ton/day) rolled powder

TABLE I.P.5
ROLLED POWDER
EFFLUENT FROM CLEANOUT OF BOTTOM OF ROTOCLONE AS IT EMPTIES INTO FIRST CATCH TANK, BLDG 6304, FIRST ROLLED POWDER AREA
RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production (x 10^3)
pH	7.50	8.10	7.80				
Specific Conductance	131.00	138.00	134.67				
Total Solids	129.00	398.00	221.00			4.97	662
Suspended Solids	3.50	98.50	38.67			0.870	116
Dissolved Solids	122.00	299.00	182.00			4.09	246
Total Organic Carbon	9.00	13.00	11.33			0.255	34
Filtered Chemical Oxygen Demand	10.00	22.00	17.67			0.397	52.8
Biological Oxygen Demand	1.00	40.00	18.33			0.412	55.0
Nitrite and Nitrate-Nitrogen	1.20	1.20	1.20			0.0270	3.6

Flow = .0027 mgd; Production = 15000 pounds/day (7.5 ton/day) rolled powder

TABLE I.P.6
COMBINED WASTEWATER FROM THE BALL POWDER AREA, BAAP 1a(2)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Temperature (°F)	53	83	62				
pH	5.7	9.2	7.3	7.36			
Conductance	300	13,500	1,220				
Total Kjeldahl Nitrogen	1.0	5.2	2.1	2.28			
Ammonia	0.50	2.45	1.31	0.74	0.57		
Nitrates	< 0.5	31.3	5.8	0.63	5.17		
Total Phosphates	~0.5	0.7	0.63	0.63			
Sulfates	36	361	247	38	209		
Chemical Oxygen Demand	42	102	72	45	27		
JTU	0.64	56	11.10	6.1			
Color (Platinum-Cobalt)	0	10	2.86	77			
MBAS	0.00	0.10	0.03	0.16			
Total Organic Carbon	20	130	63	27	36		
Total Solids	242	724	531	200	331		
Suspended Solids	0.6	15.4	8.2	13.7			
Dissolved Solids	241	715	523	186	337		

Flow = not determined; Production = 50% of capacity

TABLE I.Q.1*
NITRATOR DITCH. JAAP 1c(1)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			450 gpm				
pH			1.6				
Acidity as Calcium Carbonate			2,983			16,100	
Sulfates			2,783			15,000	
Nitrates			560			3,020	
Color (PCU)			263				

Flow = .648 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.Q.2
REFINING DITCH. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			350 gpm				
pH			2.5				
Acidity as Calcium Carbonate			165			693	
Sulfates as Sulfate			260			1,090	
Nitrates as Nitrate			55			231	
Color (PCU)			313				

Flow = .504 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.Q.3*
DRY HOUSE DITCH. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			40				
pH			12.5				
Acidity as Calcium Carbonate			0			0	
Sulfates			137			65.7	
Nitrates			33			15.8	
Color (PCU)			1,000				

Flow = .0576 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.Q.4
TETRYL PRODUCTION
DITCH A BETWEEN HALF TILE DRAIN AT BLDG 1002-7 AND FOOT BRIDGE ACROSS DITCH. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge**/ton of production
Temperature (°F)	75.0	84.0	78.1	60.0			
pH	2.2	6.6	3.1	8.2			
Specific Conductance	727.0	3,150.0	8,875.4	475.0			
Acidity	162.0	430.0	314.3	4.0	310.3	3,748	797
Alkalinity	0.0	0.0	0.0	124.0			
Color	30.0	>100.0	70.0	25.0			
Total Solids	941.0	3,012.0	1,565.1	748.0	817.1	9,869	2100
Suspended Solids	4.0	96.0	<36.7	28.0	< 8.7	<106	< 22.6
Total Dissolved Solids	866.0	3,007.0	1,528.4	720.0	808.4	8,764	1860
Total Volatile Solids	165.0	1,004.0	458.9		458.9*	5,543*	1180
Total Organic Carbon	10.3	14.4	12.5	7.6	4.9	59.2	12.6
Total Kjeldahl Nitrogen	1.6	5.5	2.6	1.0	1.6	9.3	1.98
Sulfates	580.0	1,220.0	778.6		778.6*	9,404*	2000
Sulfides	0.0	0.0	0.0		0*	0*	0*

Flow = 1.45 mgd; Production = 9,404 lb/day (4.70 ton/day) tetryl
*No correction for raw water concentrations; **Tetryl produced

TABLE I.Q.5
TETRYL PRODUCTION
DITCH B APPROXIMATELY 45 FEET EAST OF THE MAIN TETRYL DITCH. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean (A)	Mean Raw (B)	Corrected Mean (A-B)	Discharge (lbs/day)	lbs of discharge/ton of production**
Temperature (°F)	73.0	77.0	75.1	60.0			
pH	6.9	8.4	7.4	8.2			
Specific Conductance	269.0	490.0	381.4	475.0			
Acidity	0.0	20.0	13.7	4.0	9.7	37.1	7.89
Alkalinity	56.0	128.0	98.3	124.0			
Color	10.0	90.0	50.0	25.0			
Total Solids	149.0	790.0	485.3	748.0			
Suspended Solids	<1.0	78.0	<15.4	28.0			
Total Dissolved Solids	142.0	790.0	470.3	720.0			
Total Volatile Solids	61.0	677.0	268.1		268.1*	1,030*	219
Total Organic Carbon	15.0	19.8	17.3	7.6	9.7	37.2	7.91
Total Kjeldahl Nitrogen	1.3	4.3	2.4	1.0	1.4	5.36	1.14
Sulfates	97.0	133.0	116.0		116.0*	444*	94.5
Sulfides	0.0	0.0	0.0		0*	0*	0*

Flow = .46 mgd; Production = 9,404 lb/day (4.70 ton/day) tetryl
*No correction for filtered raw water concentrations; **Tetryl produced

TABLE I.Q.6*
NITRATING & REFINING HOUSES. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Tetryl			415			847	
Chemical Oxygen Demand			370			755	
Dissolved Solids			21,800			44,500	
Nitrates as Nitrate			2,700			5,510	
Sulfates as Sulfate			18,500			37,800	
pH			0.9				
Acidity as Calcium Carbonate (pH = 7.0)			19,900			40,600	

Flow = 120 gpm = .245 mgd; Production = not available
*No correction for raw water concentrations

TABLE I.R.1**

TNT PRODUCTION

SCRUBBER WATERS FROM NITRATION BLDG 9500 BEFORE FLOWING TO THE RED WATER DESTRUCTION FACILITY. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	3.00	7.20	5.43				
Specific Conductance	175.00	750.00	391.67				
Acidity	13.00	101.00	44.67			5.21	.108
Alkalinity	0.00	42.00	28.00			91.43	1.89
Total Solids	167.00	274.00	221.83			25.81	.533
Suspended Solids	<1.00	2.80	1.70			0.20	.004
Dissolved Solids	166.00	271.00	220.00			25.66	.530
Color	45.00	720.00	278.33			32.46	.670
Total Organic Carbon	9.00	13.00	11.33				
Fil Chemical Oxygen Demand	12.00	24.00	17.00			1.98	.041
Total Kjeldahl Nitrogen	2.20	3.10	2.73			0.32	.007
NO_2-NO_3/N	2.00	12.70	6.80			0.79	.016
Sulfate	24.00	146.00	73.33			8.55	.176
TNT	2.00	5.80	3.90			0.45	.009

*TNT produced

**No correction for raw water concentrations

Flow = .0014 mgd; Production = 96,893 lb/day (48.4 ton/day) TNT

TABLE I.R.2**
TNT PRODUCTION
DRAINAGE FROM OLEUM TANK CARS. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
pH	8.90	10.40	9.83				
Specific Conductance	10,300.00	15,600.00	13,700.00				
Acidity	0.00	0.00	0.00				
Alkalinity	3,820.00	28,300.00	13,123.33			1,169.70	8.07
Total Solids	942.00	31,709.00	18,180.33			1,620.43	11.2
Suspended Solids	23.00	134.00	67.00			5.97	.041
Dissolved Solids	919.00	31,665.00	18,113.33			1,614.46	11.1
NO_2-NO_3/N	0.50	5.00	2.00			0.18	.001
Sulfate	7,600.00	13,000.00	10.633.33			947.76	6.54

*TNT produced
**No correction for raw water concentrations
Flow = .0107 mgd; Production = 291,000 lb/day (145 ton/day) TNT

TABLE I.R.3**
TNT PRODUCTION
EFFLUENT FROM SETTLING TANK (FLOOR WASH WATER), BLDG 9503. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge* / ton of production
Temperature	69.0	108.0	89.1				
pH	7.6	9.3	8.7				
Specific Conductance	90.0	135.0	112.5				
Acidity	0.0	2.0	0.2			0.01	< .001
Alkalinity	48.0	79.0	65.3			3.86	.080
Total Solids	22.0	619.0	172.5			10.2	.211
Suspended Solids	1.0	41.7	7.4			0.44	.009
Dissolved Solids	13.0	577.0	164.8			9.75	.201
Color	5.0	760.0	110.9				
Total Organic Carbon	16.0	43.0	23.9			1.41	.029
Fil Chemical Oxygen Demand	11.0	33.0	16.3			0.96	.020
Total Kjeldahl Nitrogen	0.3	3.7	1.0			0.06	.001
NO_2-NO_3/N	0.2	45.0	2.7			0.16	.003
Sulfate	12.6	26.4	15.7			0.93	.019
TNT	1.8	75.4	46.7			2.76	.057

*TNT produced
**No correction for raw water concentrations
Flow = .0071 mgd; Production = 96,893 lb/day (48.4 ton/day) TNT

TABLE I.R.4**
TNT PRODUCTION
SCRUBBER WATER IN TANK OF FINSIHING BLDG 9503. RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
pH	6.90	7.70	7.37				
Specific Conductance	132.00	144.00	137.00				
Acidity	1.00	4.00	2.00			0.023	< .001
Alkalinity	63.00	75.00	68.33			0.797	.016
Total Solids	93.00	286.00	158.33			1,85	.038
Suspended Solids	2.00	2.30	2.10			0.024	< .001
Dissolved Solids	91.00	284.00	156.33			1.82	.038
Color	260.00	520.00	358.33				
Total Organic Carbon	63.00	69.00	65.67			0.766	.016
Fil Chemical Oxygen Demand	118.00	280.00	173.67			2.02	.042
Total Kjeldahl Nitrogen	2.00	3.20	2.67			0.031	< .001
NO_2-NO_3/N	2.40	6.60	4.37			0.051	.001
Sulfate	19.50	35.00	25.00			0.292	.006
TNT	145.00	1,525.00	608.33			7.09	.146

Flow = .0014 mgd; Production = 96,893 lb/day (48.4 ton/day) TNT
*TNT produced
**No correction for raw water concentrations

TABLE I.R.5**
TNT PRODUCTION
YELLOW WATER AS IT ENTERS THE CATCH TANK IN THE RED WATER DESTRUCTION AREA. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
pH	0.50	1.00	0.77				
Specific Conductance	110,000.00	185,000.00	136,666.67				
Acidity	63,000.00	171,200.00	101,533.33			1,220	8.41
Alkalinity	0.00	0.00	0.00				
Total Solids	52,238.00	137,696.00	82,930.67			995	6.86
Suspended Solids	52.50	131.00	94.77			1.14	.008
Dissolved Solids	52,185.00	137,595.00	82,835.67			994	6.86
Color	560.00	720.00	633.33				
Total Organic Carbon	1,700.00	10,000.00	4,476.67			53.7	.370
Fil Chemical Oxygen Demand	2,700.00	10,000.00	5,133.33			61.6	.425
Total Kjeldahl Nitrogen	101.00	215.00	140.33			1.68	.012
NO_2-NO_3/N	1,210.00	6,000.00	3,770.00			45.2	.312
Sulfates	56,000.00	99,999.00	85,332.67			1,020	7.03
TNT	740.00	1,600.00	1,113.33			13.4	.092

Flow = .00144 mgd; Production = 291,000 lb/day (145 ton/day) TNT
*TNT produced
**No correction for raw water concentrations

TABLE I.R.6**
TNT PRODUCTION
INFLUENT TO WASTE ACID NEUTRALIZATION FACILITY. RAAP 1n(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Temperature	75.0	96.0	86.2				
pH	1.6	7.3	3.4				
Specific Conductance	1,320.0	20,000.0	4,485.4				
Acidity	30.0	5,020.0	1,056.0			1,430	9.86
Alkalinity	0.0	760.0	59.7			80.9	.558
Total Solids	352.0	8,260.0	2,304.5			3,120	21.5
Suspended Solids	3.0	609.5	87.0			118	.814
Dissolved Solids	349.0	8,122.0	2,217.5			3,000	20.7
Color	100.0	1,200.0	574.6				
Total Organic Carbon	31.0	120.0	57.2			77.52	.534
Fil Chemical Oxygen Demand	22.0	220.0	57.3			77.7	.536
Total Kjeldahl Nitrogen	1.4	10.1	4.2			5.69	.039
NO_2-NO_3/N	12.0	610.0	63.3			85.8	.592
Sulfate	135.0	5,500.0	1,554.0			2,160	14.9
TNT	48.0	175.0	91.2			123	.848
Sodium	14.0	1,700.0	464.2			629.13	4.34

Flow = .1627 mgd; Production = 291,000 lb/day (145 ton/day) TNT

*TNT produced

**No correction for raw water concentrations

TABLE I.R.7**
TNT PRODUCTION
WASTES GENERATED IN THE SAR AREA, INCLUDING SOME ACID SPILLS, BEFORE FLOWING TO THE ACID NEUTRALIZATON FACILITY FOR TREATMENT
RAAP ln(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production*
Temperature	80	93	88				
pH	5.2	8.3	7.1				
Specific Conductance	16	76	27				
Alkalinity (as $CaCO_3$)	35.4	101.0	48.9			990	6.83
Acidity (as $CaCO_3$)	0	4.4	1.9			38.4	.265
Total Solids	90	634	229			4,640	32.0
Volatile Solids	24	102	62			1,250	8.62
Suspended Solids	45	130	68			1,380	9.52
Dissolved Solids	40	504	161			3,260	22.5
Color	5	50	17				
Total Kjeldahl Nitrogen	0.5	2.9	1.1			22.3	.154
Nitrites as Nitrogen	< 0.2	3.5	< 0.2			4.05	.028
Nitrates as Nitrogen	< 2.0	150	5.8			117	.807
Sulfates	< 25.0	1,000	52.8			1,070	7.38
Chemical Oxygen Demand	5.0	67.0	23.0			466	3.21

Flow = 2.4299 mgd; Production = 291,000 lb/day (145 ton/day) TNT

*TNT produced; **No correction for raw water concentrations

TABLE I.R.8
TNT PRODUCTION
TNT DITCH BELOW MAIN COOLING WATER DISCHARGE FROM TNT BATCH LINE 10, AREA 5. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production **
Temperature (°F)	80.0	88.0	84.0	60.0			
pH	6.4	7.6	7.2	8.2			
Specific Conductance	425.0	1,388.0	688.6	475.0			
Acidity	0.0	20.0	5.0	4.0	13.1	165	3.28
Alkalinity	84.0	304.0	154.3	124.0	30.3	283	7.58
Color	5.0	25.0	13.3	25.0			
Total Solids	594.0	925.0	753.4	748.0	5.4	68.0	1.35
Suspended Solids	1.0	84.0	43.9	28.0	15.9	200	3.96
Total Dissolved Solids	465.0	844.0	702.0	720.0			
Total Organic Carbon	12.4	17.3	15.1	7.6	7.5	94.5	1.87
Total Kjeldahl Nitrogen	0.9	8.0	3.0	1.0	2.0	25.2	.500
Nitrate-Nitrogen	15.4	17.0	16.5		16.5*	208*	4.12*
Sulfates	113.0	178.0	153.1		153.1*	1,930*	38.2*
TNT	0.0	1.3	0.8		0.8*	10.0*	.198*

Flow = 1.512 mgd; Production = 100,831 lb/day (50.4 ton/day) TNT
*No correction for raw water; **TNT produced

TABLE I.R.9
TNT PRODUCTION
RED WATER ENTERING SETTLING TANK OUTSIDE WASH HOUSE, LINE 10. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production**
Temperature (°F)	72.0	149.0	128.2	60.0			
pH	7.2	9.5	8.6	8.2			
Specific Conductance	24,000.0	37,500.0	28,200.0	475.0			
Acidity	0.0	20.0	5.0	4.0	1.0	0.500	.010
Alkalinity	2,700.0	4,000.0	3,620.0	124.0	3,496	1,747	34.6
Color	5.0	5.0	5.0	25.0			
Total Solids	25,170.0	30,220.0	27,225.0	748.0	26,477	13,233	262
Suspended Solids	20.0	58.0	41.2	28.0	13.2	6.60	.131
Dissolved Solids	25,135.0	30,168.0	27,183.7	720.0	26,464	13,227	262
Total Volatile Solids	9,690.0	13,700.0	11,856.7		11,856.7*	5,926*	118*
Total Organic Carbon	3,050.0	4,500.0	3,612.5	7.6	3,605	1,802	35.7
Kjeldahl Nitrogen	89.2	163.7	120.5	1.0	120	60.0	1.19
Nitrate-Nitrogen	7.9	8.6	8.2		8.2*	4.10*	.081*
Sulfates	8,600.0	9,000.0	8,900.0		8,900.0*	4,450*	88.3*

Flow = .06 mgd; Production = 100,831 pounds/day (50.4 ton/day) TNT
*No correction for raw water concentrations; **TNT produced

TABLE I.R.10
TNT PRODUCTION (SELLITE PRODUCED)
SELLITE DITCH ABOUT 20 FEET BELOW EARTH DAM. JAAP 1g(3)

Parameter	Minimum	Maximum	Mean (A)	Mean Raw (B)	Corrected Mean (A-B)	Discharge (lbs/day)	lbs of discharge / ton of production**
Temperature (°F)	65.0	79.0	72.0	60			
pH	2.1	7.8	5.3	8.2			
Specific Conductance	692.0	4,800.0	1,886.7	475.0			
Acidity	9.0	720.0	209.7	4.0	204.7	295	13.9
Alkalinity	0.0	382.0	125.0	124.0	1.0	1.44	.068
Total Solids	824.0	2,030.0	1,453.2	748.0	705.2	1,020	47.8
Suspended Solids	< 1.0	40.0	17.1	28.0			
Total Dissolved Solids	784.0	2,015.0	1,438.2	720.0	718.2	1,030	48.4
Total Organic Carbon	6.0	10.2	8.5	7.6	0.9	1.30	.060
Sulfates	530.0	1,400.0	928.6		928.6*	1,340*	63.0*
Sulfides	10.0	1,600.0	330.0		330.0*	476*	22.4*
T Hexane Extract	10.5	31.4	21.1		21.1*	30.4*	1.43*

Flow =.173 mgd; Production =42,509 pounds 100% sellite/day
*No correction for raw water concentration; **Sellite produced

TABLE I.S.1

AOP

WASTEWATER FROM: 2 CONDENSATE QUENCH POTS (BUILDING 33); 4 BAROMETRIC SEAL TANKS (BUILDING 334); 3 CONDENSATE COOLERS (BUILDING 302); BUILDING 302-B; AND BUILDING 300. AREA B. HAAP 1d(2)***

Parameter	Minimum	Maximum	Mean	Avg. ppm R	ppm R - ppm filtered raw water	Discharge (lbs/day)	lbs of discharge / ton of production*
Ammonia as Nitrogen	0.70	1.93		1.27			
Nitrites and Nitrates as Nitrogen	1.6	6.1		3.17	2.40	121	0.605
Kjeldahl Nitrogen as Nitrogen	0.7	2.2		1.53			
Orthophosphate as Phosphorus	<0.03	0.03		<0.03			
Acidity as Calcium Carbonate	1.2	8.9		3.4	0.5	25	0.125
Alkalinity as Calcium Carbonate	63	78		69			
Total Solids	83	346		244	20	1,000	5.00
Suspended Solids	0.2	137		0.7			
Dissolved Solids	82	346		236.6	13.6	684	3.42
Chemical Oxygen Demand	18	31		22	3.7	190	0.95
Total Organic Carbon	5	12		8			
Biological Oxygen Demand	<5	11		<5	<5**	<300**	1.5**

Flow = 6.04 mgd; Production = 400,000 lb/day (200 ton/day) 61% HNO_3

*61% HNO_3 produced

**not corrected for filtered raw water - Area B, Holston River

***assume all pollutant discharge is a result of ammonia oxidation

TABLE I.S.2

AOP

COOLING WATER FROM 2 CHICAGO PNEUMATIC CENTRIFUGAL PRECOMPRESSORS LOCATED IN THE SOUTHWEST CORNER OF BUILDING 302-B AND A PORTION OF THE COOLING WATER FROM THE OTHER BUILDING 302-B PRECOMPRESSORS. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Avg. ppm S	ppm S - ppm filtered raw water	Discharge (lbs/day)	lbs of discharge / ton of production *
Ammonia as Nitrogen	0.50	1.90		1.29			
Nitrites and Nitrates as Nitrogen	1.9	65.0		13.9	13.1	33.8	.169
Kjeldahl Nitrogen as Nitrogen	1.0	3.4		1.83	0.17	0.439	0.002
Orthophosphate as Phosphorus	<0.03	0.17		<0.03			
Acidity as Calcium Carbonate	0	5.9		1.96			
Alkalinity as Calcium Carbonate	71	91		79	3.7	9.6	.048
Total Solids	96	762		243	19	49.1	.246
Suspended Solids	0.5	3.8		1.9	1.1	2.8	.014
Dissolved Solids	93	759		315	92	238	1.19
Chemical Oxygen Demand	19	23		21	2.7	7.0	.035
Total Organic Carbon	7	26		3	4.2	11	.055
Biological Oxygen Demand	<5	9		<5	<5**	<13**	< .065**

Flow = .31 mgd; Production = 400,000 lb/day (200 ton/day) 61% HNO_3 (as 100% HNO_3)

*61% HNO_3 produced

**not corrected for filtered raw water - Area B, Holston River

TABLE I.S.3
AOP
WASTEWATER FROM AMMONIA TRANSFER OPERATION FLOWING DIRECTLY TO ARNOTT BRANCH CREEK. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Avg. ppm T	ppm T - ppm filtered raw water	Discharge (lbs/day)	lbs of discharge / ton of production*
Ammonia as Nitrogen	4.6	115.0		25.7	24.2	2.70	.014
Nitrites and Nitrates as Nitrogen	0.6	2.9		1.51	0.74	0.08	.0004
Kjeldahl Nitrogen as Nitrogen	6.0	162		30.6	28.9	3.23	.016
Orthophosphate as Phosphorus	<0.03	0.07		0.03			
Alkalinity as Calcium Carbonate	95	172		121.5	46.2	5.16	.026
Total Solids	125	277		199.4			
Suspended Solids	0.25	59.3		14.3	13.5	1.51	.008
Dissolved Solids	119	262		185.2			
Chemical Oxygen Demand	19	30		25.2			
Total Organic Carbon	7	26		14.2	0.2	0.02	.0001
Biological Oxygen Demand	<5	15		<5	<5**	<0.6**	< .003

Flow = .0134 mgd; Production = 400,000 lb/day (200 ton/day) 61% HNO_3 (as 100% HNO_3)
*61% HNO_3 produced
**not corrected for filtered raw water - Area B, Holston River

TABLE I.S.4
AOP
MINOR COOLING WATER FLOWS FROM AMMONIA UNLOADING OPERATIONS AND BUILDING 300, AND CONDENSATE RECEIVER TANK AND CONDENSATE COOLER WATER FROM BUILDING 334. AREA B. HAAP 1d(2)

Parameter	Minimum	Maximum	Mean	Avg. ppm W	ppm W - ppm filtered raw water	Discharge (lbs/day)	lbs of discharge / ton of production**
Ammonia as Nitrogen	0.3	1.6		0.9			
Nitrites and Nitrates as Nitrogen	6.0	24.0		10.4	9.6	230	1.15
Kjeldahl Nitrogen as Nitrogen	0.7	3.3		1.4			
Orthophosphate as Phosphorus							
Acidity as Calcium Carbonate	1.0	6.3		2.5			
Alkalinity as Calcium Carbonate	26	54		45			
Total Solids	329	573		467	243	5,790	29.0
Suspended Solids	3.8	13.7		7.7	6.9	164	0.820
Dissolved Solids					236	5,620	28.1
Chemical Oxygen Demand	19	56		43	25	600	3.00
Total Organic Carbon	6.0	19		9.8	1.0	24	0.12
Biological Oxygen Demand							
Grease and Oil							

Flow = 2.86 mgd; Production = 400,000 lb/day (200 ton/day) 61% HNO_3 (as 100% HNO_3)
*corrected for filtered raw water
**61% HNO_3 produced
***assume all pollutant discharge is the result of ammonia oxidation (production of weak HNO_3) operations

TABLE I.S.5*
ACID AREAS 1 & 2. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			14,700 gpm				
pH			7.2				
Acidity as Calcium Carbonate			23			4,060	
Sulfates			373			65,800	
Nitrates as Nitrate			26			4,580	
Color (PCU)			5				

Flow = 21.168 mgd; Production = not available

*No correction for raw water values

TABLE I.S.6*
ACID 3 OUTFALL. JAAP (3f)

Parameter	Minimum	Maximum	Mean	Mean Raw	Corrected Mean	Discharge (lbs/day)	lbs of discharge / ton of production
Average Flow			7,800 gpm				
pH Range			2.6-9.7				
Acidity as Calcium Carbonate			168			15,700	
Acidity Range			0-2389				
Sulfates			320			29,900	
Nitrates as Nitrate			30			2,810	
Color (PCU)			30				

Flow = 11.232 mgd; Production = not available
*No correction for raw water concentrations